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Delegates, visitors and friends, welcome to an official iNEER Conference, the “2013 Joint International Conference on Engineering Education and Research & International Conference on Information Technology” or “ICEE/ICIT-2013 Cape Town” in short. A big thank you to the Conference Organisers and the Editorial Committee, who have worked hard to organise this conference. We are all challenged to research and improve engineering education and to equip our respective countries with well skilled information technology manpower so that we can compete successfully on local and international markets. This conference focuses the attention on educational research and information technology. At the Cape Peninsula University of Technology, the Department of Information Technology’s involvement with HEICTA and iNEER continues to address these issues of national and international importance.

The programme and the impressive conference proceedings, which you already received at the registration desk, are indicative of yet another important conference. All delegates and visitors, especially those from overseas and other African States, are most welcome to enjoy what our campus has to offer and please enjoy your stay in greater Cape Town, where our university has five campuses.

Prof L V Mazwi-Tanga
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The Editorial Committee of the *2013 Joint International Conference on Engineering Education and Research & International Conference on Information Technology* or *ICEE/ICIT-2013 Cape Town* in short, has been upholding the following principles and editorial procedures:

- The Editorial Committee consists of invited senior subject specialists from a broad spectrum of local and international universities and research institutions

- In order to ensure a high standard, all abstracts of proposed conference papers are sent for evaluation to those members of the Editorial Committee, who are specialists in a particular topic

- Upon acceptance of the abstract, authors are invited to submit their papers

- Upon receipt of the paper, at least 3 reviewers are asked to blind review the paper on the web based EasyChair review system.. The Evaluation Form is completed, reflecting the rating of the quality and contents of the intended paper; how well it would fit into the forthcoming conference; the standing of the presenter; and his/her ability to present a paper, together with additional recommendations for the author(s) to consider to enhance the value of the presentation

- Each evaluator informs the relevant Track Chair of the Editorial Committee, recommending that the manuscript be either accepted; accepted with amendments; or rejected.

- The Track Chair informs each author of the outcome timeously. In some cases authors are invited to resubmit the paper based on comments made by the reviewers and the review process is repeated

- In total 169 papers have been submitted and after the review process 104 were accepted for publication in the proceedings, but 91 of them had authors attending the conference to present their paper. So 91 papers are included in the proceedings.

The peer-evaluated and refereed papers are included in a memory stick carrying an ISBN number. The conference proceedings are then distributed to all delegates upon registration.

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These Proceedings are a collection of original selected papers, which were accepted after the abstracts and full papers submitted were refereed by a panel of local and international peer evaluators, each a specialist in his or her own field. Every effort has been made to include only those papers that are original and of a high, scientific standard. The organizers and publishers do, however not accept any responsibility for any claims made by the authors.

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MPPT algorithm via VHDL programming for a CubeSat

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Abstract

The CubeSat standard has various engineering challenges due to its size and surface area limitations. One of these challenges is to deliver the maximum power to the various sub-systems. This is achieved by the Electronic Power Supply also known as the Electronic Power System (EPS).The SmartFusion FPGA was chosen to be implemented in the design of this sub-system due to its analogue front end which can reduce the amount of peripheral components required by such a complex system. The paper shows the step-by-step implementation of the Perturb-and-Observe (P&O) Maximum Power Point Tracking (MPPT) algorithm embedded on a SmartFusion field programmable gate array (FPGA) using the Libero® IDE. A VHDL implementation of the pulse-width-modulator was developed in order to produce the various changes in duty in response to the perturb-and-observe algorithm. The results show the rapid response of the SmartFusion FPGA to varying levels of solar irradiation using a minimal amount of peripheral components. This approach may be adapted to address the MPPT requirements of various solar powered devices.

Keywords: *VHDL, MPPT, CubeSat.*

1. Introduction

Solar energy is the primary source of energy for many satellites orbiting our planet. Earlier satellites employed direct energy transfer methods whereby the solar panel is directly coupled to the satellite loads. This had various drawbacks as the design required using components that were able to operate in this large range of input voltages, also, the maximum power was not always delivered to the load as there was a mismatch between the source and load impedances. Maximum power is a product of the solar cells characteristic open-circuit voltage and short-circuit current. This point varies with increasing and decreasing operating temperatures as well as changing levels of solar irradiance. MPPT is achieved through the implementation of algorithms used to change the duty cycle of a dc-dc converter in order to match the source and load impedances [1]. Digital Signal Processors (DSP's) and microcontrollers are most commonly used to implement algorithms [2]-[3] however, due to the flexibility of Field-Programmable-Gate-Array's (FPGA's), FPGA's may offer equivalent or higher performance in comparison to DSP's. The design requires an integrated analogue interface as this feature will allow the integration of multiple functions within the FPGA itself, while the FPGA itself should not require allot of board space. The paper will briefly discuss the P&O MPPT algorithm, the SmartFusion FPGA functionality, design of a maximum power point tracking circuit, step-by-step implementation of embedded MPPT algorithm as well as experimental results.

2. Perturb-and-Observe

The implementation of the P&O MPPT algorithm require only one voltage sensor or an optional current sensor in order to sense the voltage or current of the solar array. The perturb-and-observe (P&O) algorithm is thus the most cost effective and least complex method when compared to other MPPT algorithms. The algorithm works by making small perturbations in the direction of maximum power as illustrated in Figure 1taken from [4]. The figure also indicates that the maximum power point will vary with changing levels in temperature.

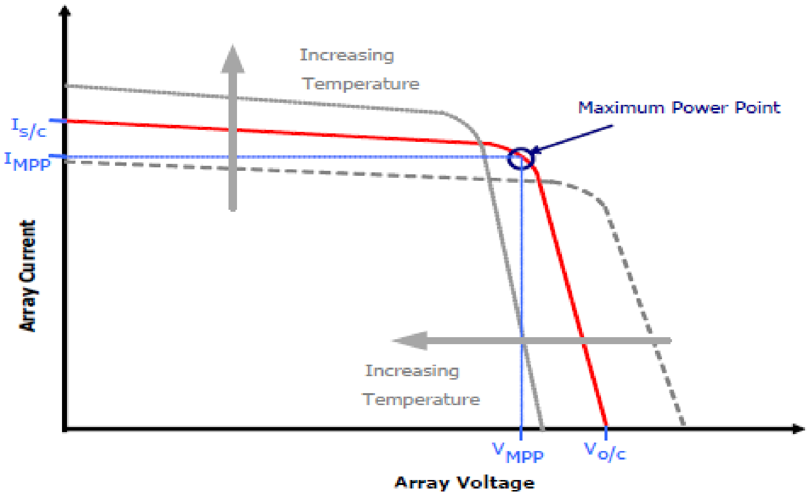

Figure 1. P&O Maximum Power Point Oscillation

3. Microcontroller Sub-System (MSS)

The MSS possess a 100 MHz Cortex-M3 processor capable of performing 125 million instructions per second (MIPS), multi-layer AHB bus matrix (AHB) that connects various peripherals [4]. The AHB bus matrix allows either the Cortex-M3 processor, FPGA fabric master, Ethernet message authentication controller (MAC) or peripheral DMA (PDMA) controller to act as masters to the integrated peripherals. These integrated peripherals may include the FPGA fabric; embedded non-volatile memory (eNVM), embedded synchronous RAM (eSRAM), external memory controller (EMC), and analogue compute engine (ACE) blocks. These features are well utilised in the EPS design as it allows the sub-system to perform complex operations at a fast rate which is required for the MPPT implementation.

4. MPPT circuit

Figure 2 shows the parameters which will be measured using the ACE of the SmartFusion FPGA. The SmartFusion FPGA will measure the voltage at the input of the PV array and the current on the output of the converter. The 50mΩ current sense resistors allow for current measurements between 250µA and 1.023A. The measurements are used in the P&O control algorithm. The control signal controls the duty cycle of the 2SK2615 MOSFET which allows the PV array to operate at maximum power.

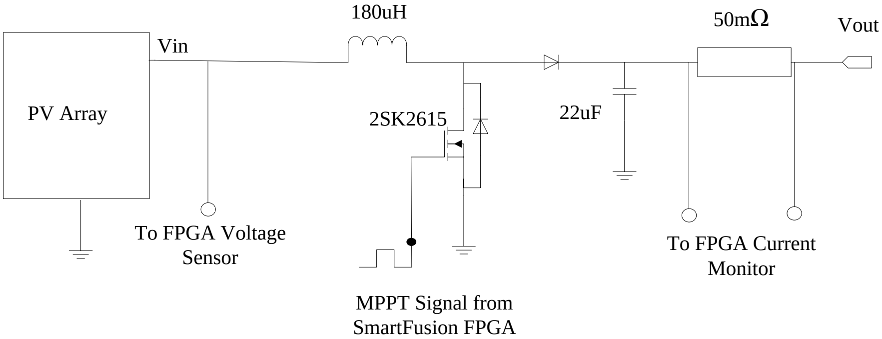

Figure 2. MPPT schematic

5. FPGA design steps

The Following major steps are executed in order to program the SmartFusion FPGA.

- Creating design
- Implement the design
- Programming device
- Firmware development

The bulk of the design layout is made during the create design phase while the implement design phase is used to verify the design and undergoes various design rule checks. Synthesis of the design, test bench simulations as well as placing the various I/O is also completed during this phase. Programming the SmartFusion device is done using FlashPro where an .fdb file is generated containing the hardware configuration of the FPGA. The Firmware development phase is used to write the application code which controls and directs the MSS which is written in C or C++. The following section handles FPGA design implementation in more detail.

5.1 Creating design

The smart design MSS is a graphical user interface (GUI) that contains a number of representative peripheral images that are actually configurable software interfaces that determine the functionality of the SmartFusion design. The MSS design canvas has different coloured blocks; the blue blocks are for hardware configuration, the orange blocks are for firmware configuration and are only configurable in the software flow; the green blocks are not configurable and the grey blocks are disabled. Blocks that have a small check box can be disabled to conserve FPGA resources and power. For this particular design application only the UART_0 and ACE blocks are checked while all other check boxes are unchecked. If I^2C interfaces are required it can be included in this step as it falls beyond the scope of this document.

5.2 Clock Management

The clock management configuration used in the design which can be found in the top left corner of the MSS design canvas. The On-Chip RC oscillator was chosen as the clock input and the Phase Lock Loop (PLL) output of 30Mhz was selected. The ACLK, PCLK0, PCLK1 and the FAB_CLK are divided by 1 to maintain the 30Mhz output frequency. FAB_CLK is used as the input clock to the PWM module which is described later in this section. Once the system clock is verified the analogue compute engine (ACE) can be configured.

5.3 Analogue Compute Engine (ACE)

To monitor the output current of the dc-dc converter used in the MPPT circuit is one of the current monitors which can also be configured using the ACE. The second current monitor is used to monitor the battery charge and discharge currents. The current monitors are constructed from switched-capacitor circuits. This allows the current monitors to have a high common mode input voltage range, a large common mode voltage rejection ratio as well as relatively high input impedance [4]. The current sensor uses an external current sense resistor of 0.05Ω allowing current measurements between 250uA and 1.02375A which is suitable for the design application. Following the selection of the different input required in the design, the sampling sequence engine (SSE) is configured in the controller tab in order to continuously sample the different input
signals.

5.4 GPIO configuration

The GPIO’s are configured in a similar manner as the above mentioned clock management and analogue compute engine. GPIO’s 0 – 7 are selected as outputs and are connected to the FPGA fabric in order to promote these pins to top level pins be able to assign package pins to these user I/O’s GPIO’s 0 – 6 are used as a 7-bit input to the VHDL PWM module while GPIO 7 is used as an interrupt enabling the MPPT algorithm. This completes the MSS configuration; however, to complete the design a VHDL PWM module needs to be created which is described in following section.

5.5 VHDL PWM

The VHDL PWM module is a 7-bit counter that counts to a value of 2^7-1 (127) before restarting at zero. This creates the saw tooth wave form shown in Figure 3. The GPIO's 0 – 6 from the microcontroller sub-system outputs binary value between 0 -127. The pwm_out signal remains at a logic high for all values of the 7-bit pwm_value which are greater than the counter value and switches to a logic low as soon as the pwm_value is less than the counter. This logic is confirmed through the implementation of a user test bench.

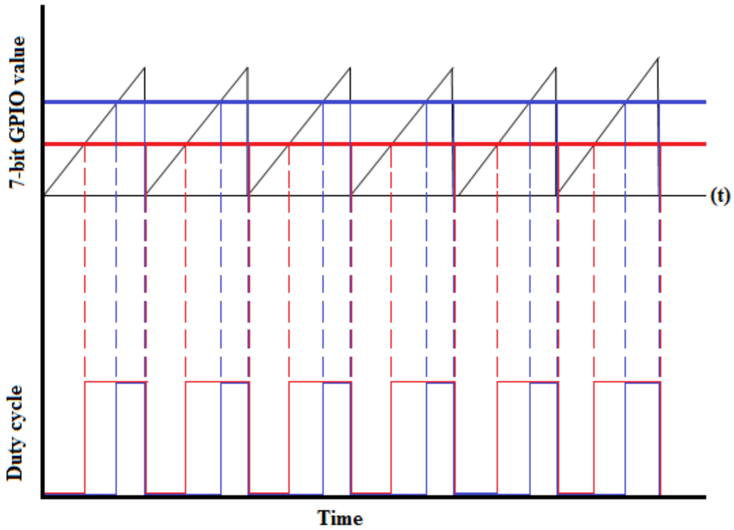

Figure 3. VHDL PWM operation

The VHDL component show in Figure 4 is generated under the create design tab in the design flow window and by selecting create new HDL file option. In the design hierarchy window the HDL file is listed which allows for a HDL syntax check. Once the syntax check has completed the VHDL module can be instantiated into the MSS design allowing the connection between the MSS and VDHL PWM module which is shown in

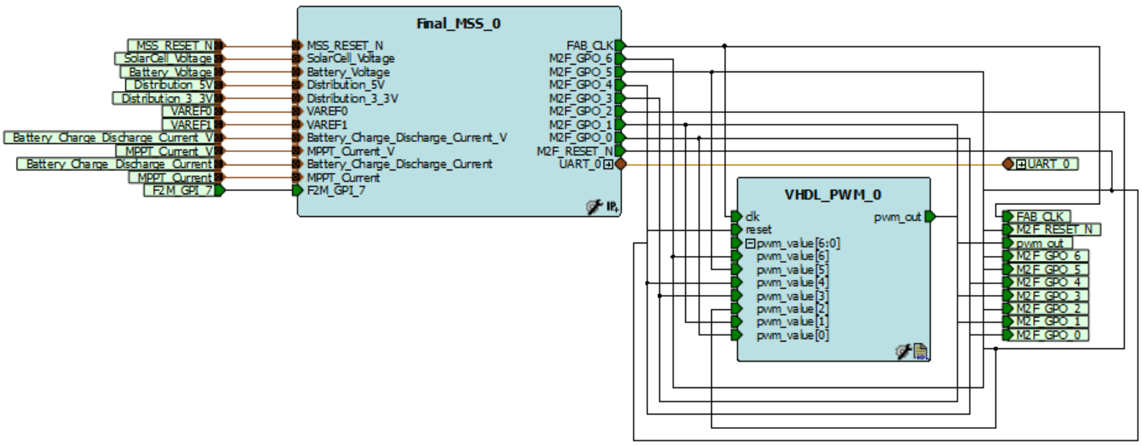

Figure 4. MSS and VHDL PWM

5.6 VHDL TEST BENCH

The user test bench is written using VHDL. The test bench is written in order to confirm the operation of the VHDL module. The test bench produces simulated results by testing the operation of the module under various input conditions. The conditions used to test this module involved the setting of the pwm_value signal to represent different input signal from the MSS GPIO's in order to induce changes in the pwm_out signal. Setting the amount of clock periods before a change in the state of the pwm_value signal as well as the reset conditions were also set. The simulation runtime was set to 60µs.The test bench allowed the value from the MSS GPIO's to change from 0, 32, 64, 95 and 127 representing 0%, 25%, 50%, 75% and 100% duty cycles respectively.

5.7 Programming Device

The data files generated during the place and route procedure required for programming can be accessed using FlashPro®. FlashPro® allows for the configuration of the device loading the .pdb file onto the FPGA flash memory. The SmartFusion FPGA Eval-kit jumpers should be placed in the correct positions to allow for FlashPro® programming.

5.8 Firmware Development

After the FPGA has been programmed Softconsole® is used to write the application code used in the firmware development phase.

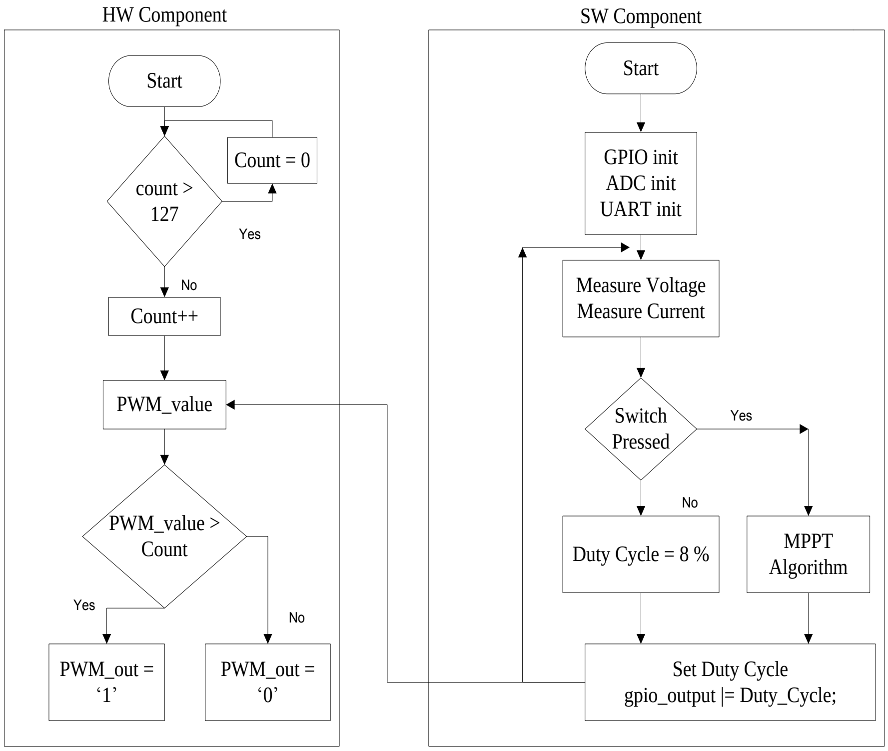

Figure 5. SmartFusion FPGA Application code Flowchart

Error! Reference source not found.5 shows the application code flowchart for both the hardware and software components. The hardware component indicates the VHDL flow chart of the VHDL PWM where a counter was initialised which value is compared to that of the 7-bit GPIO PWM_value signal. The software component shows the sequence in which the program is executed. A feature that was added is that of the switch. The switch allows the program to enter MPPT mode or exit it. This feature may become important when the CubeSat is not required to operate in MPPT mode. A default duty cycle was chosen to produce the 4.2V output.

6. MPPT verification

The experimental setup shown in Figure 6 was used to determine the performance of the maximum point tracking circuit. The solar cells were connected in a 1 series 3 parallel connection with the active load tuned to 6Ω in order to draw maximum current. The sample sequencing engine is able to take a MPPT current measurement every 47.067µs. This indicates that in order to achieve a time scale of 1000ms 21246.308 samples need to be taken, however, 1 sample was taken every 4ms thus only 250 sample were needed to obtain a 1000ms time scale.

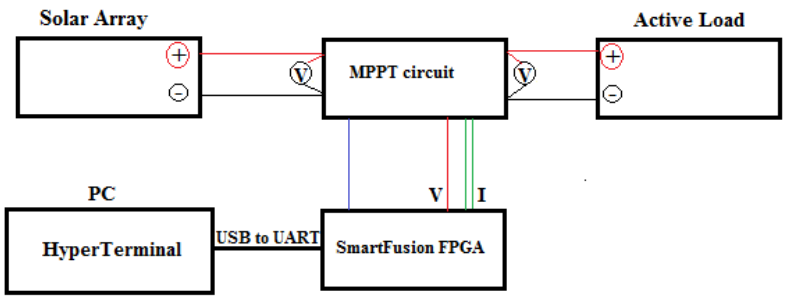

Figure 6. MPPT experimental setup

While the maximum power point tracking algorithm was not allowed to operate approximately 200mA was drawn from the solar panels. Figure 7 indicates that at 310ms the maximum power point tracking algorithm was allowed to operate and an increase in solar cell output current can be seen. The output current increased from 200mA and fluctuates between 653mA and 681mA. The input current at this moment was measured at 721mA showing an efficiency of 90.56% and 94.45% which is a satisfactory result as power system efficiency of 76.5% was set as a design requirement. The reason for the fluctuation is due to the perturbation around the maximum power point which may be addressed by decreasing the size of the perturbation. The efficiency shows that the maximum power point circuit dissipated 7% of the solar power available. The results indicate that 194ms is required in order to determine the maximum power point when switching from low level of solar irradiance to a high level of solar irradiance while Figure 8 shows that 347ms is required to move from a high level of solar irradiance to a low level of solar irradiance. The maximum power point was achieved in 347ms at worst case which is slightly faster than that of Bester, 2011 who achieved 419ms at worst case as well as the 1s settling time achieved by Lee, Bae & Cho, 2006. The power consumption of the EPS was estimated as 330mW as indicated in the power budget, however, the SmartFusion FPGA consumes only a worst case of 148.93mW showing a 55% decrease in power consumption from the estimate.

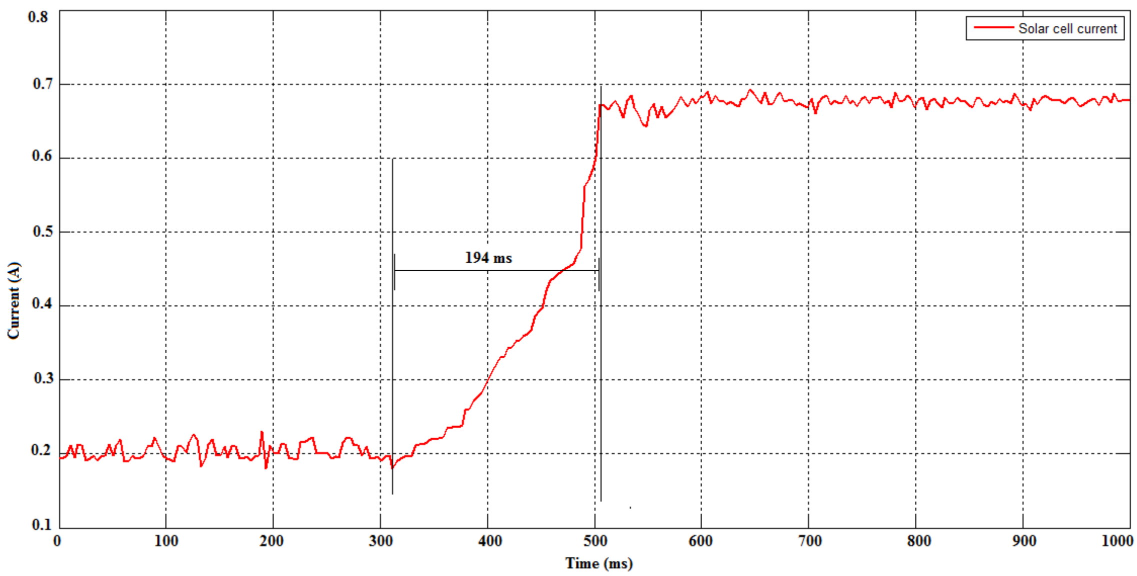

Figure 7. MPPT performance switching from low level to high level of solar irradiance

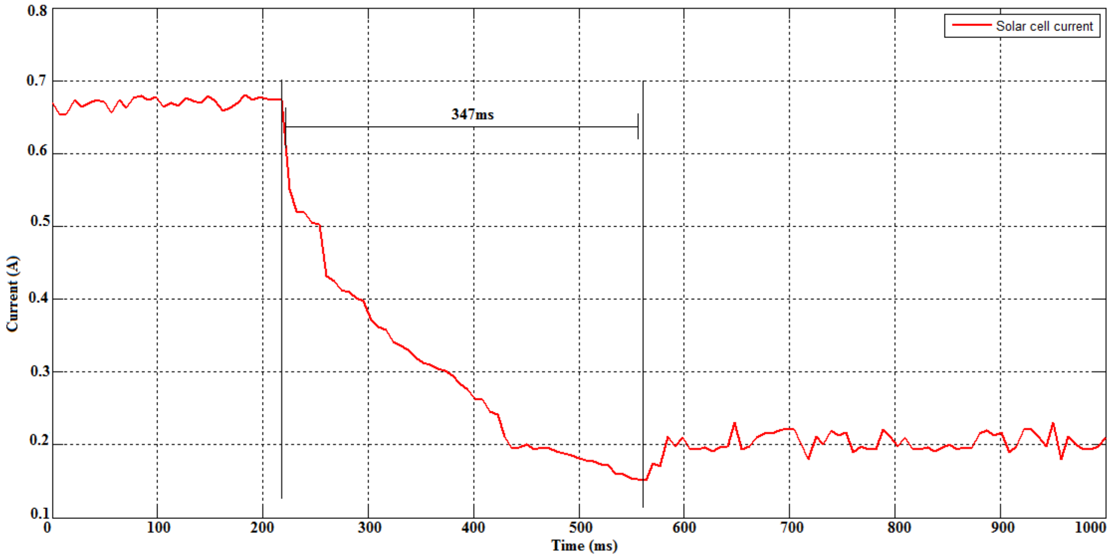

Figure 8. MPPT performance switching from low level to high level of solar irradiance

7. Conclusion

The SmartFusion FPGA analogue compute engine allows for complex MPPT algorithms to be implemented on the microcontroller sub-system as it allows for the offloading of many repetitive calculations which allows the microcontroller sub-system to perform functions with higher accuracy and increased performance. The SmartFusion FPGA offers a high level of integration as it contains ADC's, an ACE, sampling sequencing engines and post processing engines, decreasing the component count of non-FPGA control based Nano-satellite power systems. The aforementioned features optimizes the EPS-system even more as the sampling sequencing engine captures the information from the ACE and passes it to the post processing engine where the data can be transformed and filtered. These actions ensure that during high microcontroller activity sample sequencing occurs and information required for calculating the MPPT is not lost thus improving the reliability of the system. To limit the power consumption of the FPGA the full functionality of the FPGA was not utilized. Using the FPGA with its integrated VHDL MPPT components decreased the component count through the utilization of the analogue front end and the analogue compute engine. These unique features of the SmartFusion FPGA allows for decreased time for prototyping.

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Presenter: This paper is presented by Stephen Cupido

Telecommunications

Spam Electronic Mail Detection with Support Vector Machines

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Abstract

There has been a steady increase in e-mail spam, known as unsolicited bulk e-mail (UBE), junk mail, or unsolicited commercial e-mail (UCE). A literature review indicates many spam filters available employing various techniques to identify spam. However, some risks are associated including classifying legitimate mail as spam. Cases where filtering is avoided have led to adversely draining valuable resources such as bandwidth or storage capacity, thereby to loss in productivity. This paper addressed the problem of spam e-mails through a supervised machine learning algorithm (support vector machine). The classifier learnt the features of the spam dataset and the model built identified spam and benign e-mails. Results from the classifier were evaluated with metrics such as true positive, false positive, precision, recall and accuracy using a polynomial kernel function.

Keywords: Spam, e-mail, support vector machines.

1. Introduction

Electronic mail, often abbreviated as e-mail, email or eMail, is creation, transmission or storage of text-based human communications via digital communication systems [1]. E-mail was widely accepted by the business community as the first broad electronic communication medium and was the first e-revolution in business communication. Today, e-mails are a commonplace and convenient medium for daily communications. However, all is threatened by four phenomena - e-mail bombardment, spamming, *phishing* and e-mail worms [1]. Spamming is unsolicited commercial (or bulk) e-mail. Low cost bulk e-mail enables spammers to daily send millions of messages resulting in unsolicited information overload.

It is estimated 75% of all e-mails are unsolicited, i.e. spam [2]. Unlike traditional junk mail spam can be sent with little or no cost to the sender [3]; cost to a recipient, however, can be enormous. It cost companies billions annually in terms of lost employee productivity on top of money spent on anti-spam tools. Reliable, cheap, simple tools are needed to detect spam. The simplest technique nowadays is the spam filter. When e-mail passes through a filter, if it is an unsolicited mail it is dropped into a junk folder, if ham (genuine mail) it is sent to an inbox [4]. In addition, other solutions available act as a model for automatic spam detection based on machine learning and data mining technique such as classification, clustering and genetic algorithms that classify spam e-mails and select their relevant features [5].But there remains a lack of useful features to efficiently distinguish between spam and non spam; classification techniques continue to exercise a high growth of “false positives” in different spam detection systems. This paper focuses on the use of a support vector machine classifier using a polynomial kernel function for classifying solicited (ham) and unsolicited (spam) e-mails.

The remainder of the paper is: Section 2 presents related works; Section 3 describes the architecture of the proposed system; Section 4 proposes method and mathematical model; Section 5 examines dataset discussion and simulation results; conclusions are given in Section 6.

1.1. Related Works

The authors of [6] proposed a decentralised privacy preserving approach to spam filtering. The solution exploits robust examination to identify messages that vary slightly from one another and structured peer-to-peer architecture between mail servers to collaboratively share knowledge on spam. In [7] the authors specify the algorithm aims to detect spam web pages. In this algorithm, the web pages gain the spam rank value through forward links - links of reverse direction used in traditional link-based algorithms.

The authors of [8] introduced a novel hybrid model, Partitioned Logistic Regression. It exhibits several advantages over both Bayes and Logistic Regression by separating original feature space into several disjointed feature groups. Also [9] studied the application of Random Forest (RF) to spam filtering. The Ling Spam and Corpora with 10 –fold cross validation were used, selecting 256 features based on either information or a proposed term frequency variance, RF produced the best overall results. In [10] architecture was proposed for collaborative agents -algorithms running in different clients interacting for message classification. Individual methods considered included NB, Fisher's Probability Combination method, DT and neural networks. In the framework developed, classification given by each method was linearly combined with the weights of the classifier that agree/disagree, with overall result being increased/decreased. The authors argued the proposed framework produced important advantages, such as robustness to failure of single methods plus simple network implementation.

In [11] the authors offered a spam filter system using semantics in spam filtering by representing e-mails with an information retrieval model. In [12] work in 2012 showed effectiveness of using hybrid similarity measure feature representation methods and refined neural network algorithms in spam filtering. In [13] a novel spam filtering technique, based solely on the information present in headers, was introduced.

2. Proposed Method

The proposed method uses the concept of a support vector machine (SVM); concept background is:

2.1 Support Vector Machines

SVM are a set of related supervised learning methods used for classification and regression [14]. They belong to a family of generalised linear classifiers. They may also be considered as a special case of Tithonov Regularization [15] - a method based on statistical learning theory and mathematical optimisation. The technique operates by selecting an optimal hyper-plane that maximises a class separating margin to divide samples into different classes. It was decided to divide e-mails into spam and non-spam. The basic method of SVM is to non-linearly map the original feature vector into a space of higher dimension in which data can be linearly classified as shown in Figure 1. SVM employs a kernel function, which allows calculating the hyper-plane without performing a mapping step [16]. SVM is the most efficient and widely used classification tool among others and has a competitive advantage over methods such as LDA (linear discriminated analysis) neural network and decision trees. It is based on the convex optimisation problem (quadratic criterion with linear constraints, so it does not suffer from local minima problem).There are four basic concepts associated with SVMs - separating hyper planes, the maximum-margin hyper-plane, the self-margin and the kernel function. SVM has been successfully used in many applications such as decision support [17], software reliability identification [18], pattern recognition [19], bioinformatics [20], [21], oil and gas ([15], [22]) network security [23] and defect prediction in software-engineering [24]. The work of [22] shows that SVM has ability to deal with small dataset and ease of training. In terms of execution time and correlation co-efficient, they presented SVM as a close match to functional networks which are an extension of neural networks. In [25] support SVMs have been proposed as a new intelligence framework for predicting PVT properties of crude oil systems based on structure risk minimisation criterion and soft margin hyper-plane. In this work, after training the SVM in regression, the model was ready for testing and evaluation using across-validation criterion.

Comparative studies compared performances and accuracy of the SVM versus standard neural networks and the three common published empirical correlations - Al-Mahroun, Glaso and Vasquez/Beggs.
The performance was evaluated and in implementation, three distinct kernel functions were used: polynomial, sigmoid kernel and Gaussian bell kernel. The model demonstrated high accuracy (SVM has E_A =1. 368% , r= 0.9884 while ANN has E_A= 1.7886%, r=0.9878) in the prediction of PVT values with a stable performance and achieved the lowest absolute percentage relative error, lowest minimum error, lowest maximum error, lowest root mean square and highest correlation co-efficient.

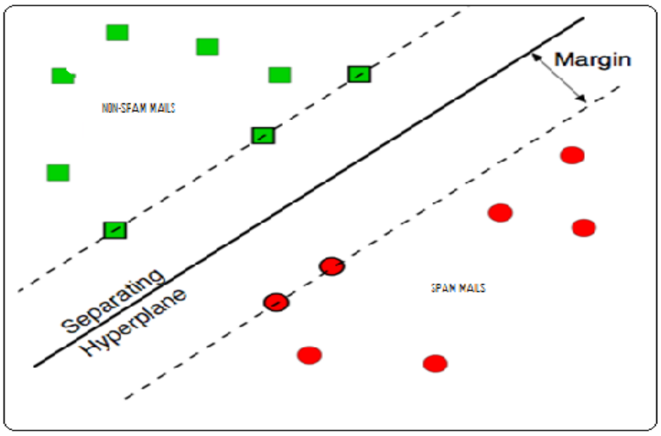

Figure 1: Maximum margins; vectors on dashed lines are support vectors

2.2 Mathematical Model:

Let the spambase training sample be $\{x_i, y_i\}_{i=1}^{N}$ where x_i is the sample input model, $y_i \in \{-1, 1\}$ here the classification problem is to categorise tags for each sample in order to find the equation $f(x)$. The null data and positive data are separated through the separating hyper-plane.

The separating hyper-planes
This is a general term for a straight line in a high-dimensional space and so the separating hyper-plane is essentially the line that separates the spam mails and non-spam mails. If the positive $(x_i = +1)$ and the negative $(x_i = -1)$ data points from the learning set, then the two can be separated by a hyper- plane.

$$\{x : f(x) = b + w.x_i = 0\} \quad (1)$$

EG: If the hyper-plane can separate the learning set into two classes without error, it is named a separating hyper-plane (SH).
The maximum-margin hyper-plane
This is a function SH which maximises its margin and written as:

$$f(x) = b + x.w$$

$$= b + \sum_{i \in SV} \alpha_i y_i x^T x_i \quad (2)$$

And the classification rule is given by

$$(x) = sign\{f(x)\} \quad (3)$$

The soft Margin
This specifies a trade-off between hyper-plane violations and the size of the margin the soft margin optimisation problem is to find w, b and to:

Minimise $\frac{1}{2}\|w\|^2 + C\sum_{i=1}^{n}\varepsilon_i{}^2$ (4)

Subject to $\varepsilon_i \geq 0$, $y_i(\langle w..x_i \rangle + b) \geq 1 - \varepsilon_i$ i=1, 2,….., n

Where C>0 is a regularisation parameter. According to [26] the dual is given as:

$$\max \sum_{i=1}^{n} \alpha_i - \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} y_i y_j \alpha_i \alpha_j \langle x_i, x_j \rangle - \frac{1}{2C} \sum_{I=1}^{n} \alpha_i^2 \tag{5}$$

Subject to

$$\sum_{i=1}^{n} y_i \alpha_i = 0$$

$$\alpha_i \geq 0$$

$$i = 1, \ldots\ldots, n$$

$$\max \sum_{i=1}^{n} a_i - \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} y_i y_j \alpha_i \alpha_j K \langle x_i, x_j \rangle - \frac{1}{2C} \sum_{I=1}^{n} \alpha_i^2 \tag{6}$$

Finally according to [26] the discriminant function is:

$$f(x) = \mathrm{sgn}(\sum_{i=1}^{n} \alpha_i y_i K(x_i.x) + b) \tag{7}$$

The kernel function is a mathematical concept permitting a SVM to perform a two-dimensional classification of a set of originally one-dimensional data that projects data from a low dimensional space to a space of higher dimension. So for any given dataset with consistent labels there exists kernel functions that permits data to be linearly separated. The major kernel function considered in this paper is the polynomial kernel, stated as polynomial.

$$K_{POLY}(x_i, x_j) = (c + x_i.x_j)^d \quad c > 0 \tag{8}$$

Where c and d are kernel parameters that is c is a constant term and d is the degree of the polynomial. The training vectors x_i are mapped into a higher (maybe infinite) dimension). Other kernels include the linear kernel, Gaussian Kernel Function (Radial Basis Function)

$$K_{LIN}(x_i, x_j) = x_i.x_j \tag{9}$$

$$K_{RBF}(x_i, x_j) = \exp(-\gamma \|x_i - x_j\|^2 \tag{10}$$

SVM Algorithm

1. Select the parameter C representing the trade off between minimising the training set error and maximising the margin. Select the kernel function and any kernel parameter in this case polynomial kernel and its parameter.
2. Solve the SVM formulation using an appropriate quadratic programming or linear programming algorithm
3. Recover the primal threshold variable by using the support vectors
4. Classify a new point x as follows

$$f(x) = Sign(\sum_{i=1}^{n} y_i x_i k(x_i.x) + b)$$

Where $k_{pol}(x_i, y_i) = (1 + x_i.y_j)^d$

$$f(x) = Sign((\sum_{i=1}^{n} y_i x_i (1 + x_i.x_j)^d + b) \tag{11}$$

3. Proposed Architecture

During the training phase, the e-mail dataset is first processed by passing through feature extraction and feature selection before passing the dataset through the classifier which will build the model from which other datasets will learn. The test dataset is passed through the same feature selection process and used to classify the dataset into spam and non-spam e-mails, using the previously learnt model.

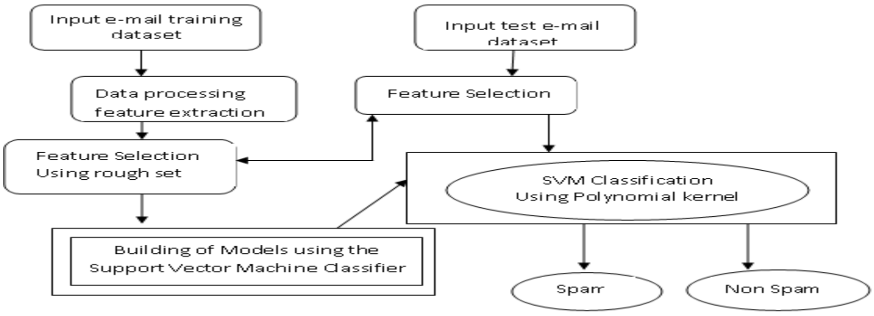

Figure 2: Proposed architecture for e-mail spam detection

3.1 Dataset Description

The dataset considered was the Spam base dataset (training) as described in Table 1.
It is comprised of 4 601 ‘instances’ with 58 attributes of which 1 813 represent spam emails and 2 788 non-spam e-mails. This dataset consists of tagged e-mails from a single e-mail account and an explicit description of the attributes of the datasets is found in Table 2. Another dataset – spam base...test.arff contained a binary vector representing one spam e-mail with 55 attributes. The classifier was used to evaluate both training and test dataset.

Table 1: Spam base dataset description

Name of Dataset	Spam	Non Spam
Spambase	1813	2788

Table 2: Attributes of spambase dataset

Attribute	Description
Wordfreq w	48 attributes describing the frequency of word w, defined as the percentage of words in the e-mail that match w, i.e., 100 * (number of times the w appears in the email) / total number of words in email.
char freq c	6 attributes describing the frequency of a character c, defined in the same way as word frequency.
	This describes the average of longest uninterrupted
ital run	sequence of capital letters.
;th average	This describes the length of longest uninterrupted
ital run	sequence of capital letters.
;th longest	This describes the total number of capital
ital run	letters in the e-mail.
;th total	the target attribute denoting whether the
m Class	e-mail was considered spam or no-spam.

3.2 Simulation

Weka software was used to train a SVC to detect spam. Some pre-processing of data was done prior to it being made available. The pre-processing included removing some attributes in the training dataset to make it compatible with that in the test dataset. Some attributes removed included capital_run_length_average, capital_run_length_longest and capital_run_length_total attributes. The attributes in the trained dataset had to be changed from numeric to binary using a function in WEKA to be compatible with the test dataset. Eventually, each representation of an e-mail was converted to a 55 dimensional vector representing whether or not a particular word exists in an e-mail. The dataset spam-trained using the SVM classifier was able to distinguish spam mail from non-spam. During the training phase, the e-mail dataset was first processed by passing through feature extraction and feature selection before passing it through the classifier which built the models. The test dataset was passed through the same feature selection process and used to classify the dataset into spam and non-spam e-mails using the previously learnt model. This simulation used the WEKA software environment; all tests were on a 2.53GHz Intel Core 2 Duo Computer with 2GB of RAM.

3.3 Evaluation

Evaluation of the classifier was completed using the following metrics - accuracy, precision, recall, false positives, false negative, true positives and true negatives. The true positives were referred to as the spam e-mails; the false negatives as spam e-mails, identified as non-spam while the false positive are the non-spam e-mails identified as non-spam and the true negatives as non-spam e-mails and identified as non-spam. Other metrics were given in the form of equations; Overall accuracy: Accuracy is the percentage of correctly classified modules [27]. It is one of the most widely used classification performance metrics [28]

$$\text{Accuracy} = \frac{(TP + TN)}{(TP + FP + FN + TN)} \tag{10}$$

True positive (TP): TP is the number of correctly classified fault-prone modules. TP rate measures how well a classifier can recognize fault-prone modules. It is also called sensitivity measure [28].

$$\frac{Truepositive}{sensitivity} = \frac{(TP)}{(TP + FN)} \tag{11}$$

While false positive (FP): FP is the number of non-fault-prone modules that is misclassified as fault-prone class. FP rate measures the percentage of non-fault-prone modules that were incorrectly classified.

$$\text{False positive} = \frac{(FP)}{(FP + TN)} \tag{12}$$

Precision: This is the number of classified fault-prone modules that actually are fault-prone modules [28]

$$\text{Precision} = \frac{(TP)}{(TP + FP)} \tag{13}$$

Recall: This is the percentage of fault-prone modules that are correctly classified. [28]

$$\text{Recall} = \frac{(TP)}{(TP + FN)} \tag{14}$$

4. Results and Discussion

Experimental results of the SVM classifier in detecting e-mail spam on the WWW used the spam base dataset .Table 4a, 4b, 5a and 5b summarises the performance of this classifier on both training and test datasets and compares results with other support vector machine kernels.

Table 4a: Evaluation on spambase training dataset

Classifier	Catalog	Results			
		True Positive	False Positive	Precision	Recall
SVM	Normal	0.957	0.095	0.939	0.957
LINEAR	Spam	0.905	0.043	0.931	0.905
M	Normal	0.993	0.039	0.975	0.993
Y	Spam	0.961	0.007	0.989	0.905
SVM	Normal	0.928	0.115	0.928	0.962
RBG	Spam	0.938	0.038	0.938	0.885

Table 4b: Evaluation on spambase test dataset

Classifier	Catalog	Results			
		True Positive	False Positive	Precision	Recall
SVM	Normal	0	0	0	0
LINEAR	Spam	1	0	1	1
M	Normal	0	0	0	0
Y	Spam	1	0	1	1
SVM	Normal	0	0	0	0
RBG	Spam	1	0	1	1

Table 5a: Evaluation on spambase training dataset

Classifier	Accuracy
SVM LINEAR	93.6318%
SVM POLY	98.0439%
SVM RBG	93.1337%

Table 5b: Evaluation on spambase test dataset

Classifier	Accuracy
SVM LINEAR	100%
SVM POLY	100%
SVM RBG	100%

From these results the evaluation of the spambase on the training dataset indicates SVMs with a polynomial kernel en joys better overall accuracy in classifying e-mails into spam and non-spam. In Table 5b, simulations show accuracy of SVMPOLY is the highest with 98.0439%, followed by SVM linear with 93.6318% and lastly SVMRBG with accuracy of 93.1337%.

The results on precision for normal e-mails also show SVMPOLY the highest with 0.975 in detecting normal e-mails followed by 0.939 for SVMLINEAR and 0.928 for SVMRBG. Hence, SVMPOLY has the highest capability of correctly classifying normal e-mails that are normal e-mails. The results on precision for spam e-mails also show that SVMPOLY is the highest with 0.989 in detecting spam e-mails followed by 0.938 for SVMRBG and 0.931 for SVMLINEAR. Hence, SVMPOLY has the highest capability of correctly classifying spam e-mails that *are* spam e-mails. Recall results on normal e-mails show a similar trend; here SVMPOLY has the highest value of 0.993 followed by 0.957 in SVMLINEAR and 0.962 in SVMRBG. These values show SVMPOLY has the highest percentage of classifying spam e-mails as spam e-mails. Recall results on spam e-mails show SVMPOLY and SVMLINEAR with similar results of 0.905 and SVMRBG with a value of 0.885. These values indicate SVMPOLY and SVMLINEAR exhibit the highest percentage of classifying spam e-mails as spam. Simulation also gave true positive results of 0.993 for SVMPOLY, 0.957 for SVMLINEAR and 0.928 for SVMRBG. This implied SVMPOLY had a capability of correctly classifying normal e-mails .Also, results of 0.961 for SVMPOLY, 0.938 for SVMRBG and 0.905 for SVMLINEAR showed SVMPOLY also had the best possibility of classifying spam e-mails as spam.

False positive on normal e-mails give results of 0.039 for SVMPOLY, 0.095 for SVMLINEAR and 0.115 for SVM RBG and showed SVMPOLY had the lowest capacity of misclassifying normal e-mails as spam. False positive results on spam e-mails were such that SVMLINEAR produced 0.043, followed by 0.007 for SVMPOLY and 0.038 for SVMRBG. This eventually implied SVMPOLY had the lowest capacity of misclassifying spam e-mails as normal. Evaluation on the test dataset showed the SVM classifier using the three different kernels able to correctly classify the test dataset with 100% accuracy. This was a result of the test dataset containing a single instance with 55 binary attributes; therefore, the SVM classifier was able to classify the test data accurately as spam.

5. Conclusions

Experimental results of this paper demonstrated the polynomial SVM performed better than other SVM techniques such as linear SVM and radial basis functioning SVMs. Experiments in this paper are based on the spambase dataset as benchmarks. Further works will use other benchmarks such as the Corpora Ling Spam and Spam Assassin dataset to indicate ability of support vector machine classifier for generating a high accuracy and decrease the time of computing.

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Presenter: The paper is presented by Oluwatoyin Odukoya

Design in ICT and/or Engineering Practice

Development of an Improved Multi-Factor Authentication Scheme for Internet Banking

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Abstract

Data compromise is a major challenge for the Internet banking system. Several schemes have been proposed to mitigate attacks against users; this includes use of passwords, which are vulnerable to keyboard sniffers, password guessing and shoulder surfing. The need to accurately and reliably authenticate users is the motivation behind this study. In this paper, a multi-factor authentication technique is formulated by integrating three entity authentication policies. The technique is characterised by the use of unique factors of authentication at different points in a transaction process. The model was transformed into an algorithm and simulated with Matlab. A set of passwords, challenge questions, token codes and iris images were obtained to serves as input data to the simulated model. Performance comparison of the proposed model with an existing model was carried out using false acceptance rate (FAR) and false rejection rate (FRR) as metrics. The simulation result for the proposed and existing scheme showed a 100% and 95% Success Rate respectively. The proposed scheme can substantially strengthen the overall security of internet-based bank transactions and effectively protect customers' sensitive information.

Keywords: *Data compromise, Internet banking, multi-factor, entity authentication, performance, information security.*

1. Introduction

Society depends heavily on computers. One benefit is computers' ability to communicate with one another creating networks. In most cases, network computing is cost-effective from the pooling of resources [1] [2].

Economic and social factors may lure network users into data compromise. A dishonest party can access and sometimes be able to control a communication. Protection against malicious activities [3] using various network security mechanisms is among the main objectives of building a dependable system.

Financial institutions use communication networks for storing, processing, and exchanging private and critical information. A basic network infrastructure normally does not provide any guarantee to a communicating party about the state of other parties on the network [4]. Therefore, a layer of protocols is employed for reliable communication and synchronisation of the states of communicating parties.

An important goal of network security is entity authentication [5], which refers to the process where one party, the verifier, clears the claimed identity of another communicating party, the claimant. Usually, the claimant presents claimed identity to a verifier with evidence to support any information.

Entity authentication is a natural requirement for Internet banking (a possibility to initiate financial transaction via Internet connection to one's bank or other financial institution) transactions. Authentication enables a manager to prevent unauthorised parties from using a private network, while allowing the actions of authorised parties. Without authentication, an adversary can pretend to be an authorised party and could play an intermediate role between honest parties.

To bind identity more closely to an entity and appropriate authorisation, a strong identity convention must be in place. This should not be based only on what a person has (smart cards) or knows (passwords) but in addition t physical characteristics or personal behavioural traits - biometrics. These are measurements of behavioural or physical attributes; how an individual smells, walks, signs their name, or even types on a keyboard, their voice, fingers, facial structure, vein patterns or patterns of an eye's iris. Form more than a decade financial institutions have seen an increase of Internet-banking abuse. Since Internet banking is widely used, criminal users have proliferated- organised criminal attempts are commonplace. Therefore, financial institutions need to implement robust controls as the transaction risk level increases.

This paper introduces a multi-factor (combination of more than one authentication factor) technique, ensuring a higher level of security to Internet banking applications. The scheme implements use of unique authentication factors at different points in a transaction process so the strength of one factor compensates for the weakness of another. This can substantially strengthen the overall performance of Internet-based services by reducing account takeovers and resulting financial loss.

The rremainder of this paper is: Section 2 presents a brief literature review of previous work in the field of entity authentication; Section 3 is a description of methodology adopted; Section 4 details experimental results; Section 5 discusses and analyses results of the experiments and general conclusions are made in Section 6.

2. Literature Review

Much research has been performed in the field of entity authentication; many models have been developed. In [6] Yoon *et al.* propose a scheme to address the problem of insecurity in remote access of Internet and wire/wireless communication environments. The scheme adopted bit-wise exclusive-OR (XOR) operation and collision-free one-way hash functions as main cryptographic operations to provide flexibility in a biometrics remote user authentication scheme via smart cards - in a quest to achieve security, reliability and efficiency. However, the scheme proved vulnerable to impersonation in the event of a smart card loss.

To address the vulnerability of session password to shoulder surfing; Sreelatha *et al.* [7] proposed a pair-based, hybrid textual authentication scheme suitable for use in Personal Digital assistants (PDA). The method generated session passwords using text and colours. Ramasamy *et al.* [8] proposed a scheme to reduce authentication attacks, using password RSA cryptography embedded in a smart card in a bid to provide authentication with reasonable computational cost. In their own scheme Chandran *et al.* [9] integrated fingerprint and iris scenario using multiple sensors for data acquisition. The integration of iris and fingerprint biometrics to overcome hurdles of uni-modal biometric system accomplished the purpose of a reliable and accurate identification/verification using biometric technologies.

To enhance security with an optimal overall time taken for the grid operation, Jaspher *et al.* [10] combined location factor: 'some place the user is'; with password and biometric data to propose a privacy preserving biometric authentication scheme for a grid environment. Liao *et al.* [11] presented their Diffie-Hellman key agreement protocol to encrypt /decrypt communicated messages with symmetric cryptosystem for prevention of system resources fraud by illegal users over insecure networks. For Patel *et al.* [12] resolving security issues evolving from entity authentication was a concern. Their solution for accurate identity authentication was based on pattern recognition of human iris; the scheme is applicable to many authentication systems, enhancing security and eliminating fraud.

An algorithm based on local binary pattern and histogram approaches for feature extraction, and a linear vector quantisation classifier for classification was developed by Suganthy *et al.* in [13]. They designed the scheme to distinguish valid from unauthorised users during an identity check. The major advantages of their system were its requirement of few components on implementation and effectiveness of integration within security systems. In their survey of different iris recognition methods to build integrated classifier on latest input device, Sheela *et al.* [14] explored discrete cosine transforms, corner detection and parametric template methods to provide a measurable physical attribute for authentication.

They recommended the application for accuracy and speed in secure communications and mobile commerce.

Rama *et al.* [15] proposed a fusion mechanism amalgamating a canny edge detection scheme and a circular Hough transform, to detect the iris boundaries digital eye images. The scheme integrates iris recognition with a smart card to develop a high security access environment for reliable human authentication in automated teller machines (ATMs).

In fingerprint-based online banking authentication scheme proposed by Singhal *et al.* [16].Statistical, spectral and structural texture analysis techniques was used in the analysis and classification of fingerprint images. This model has an advantage in a low cost fingerprint identification system operable with small computers. However, the password factor in this scheme factor was static in nature hence prone to replay attack and impersonation, since a one-time registration used over time; the fingerprint biometric authentication is prone to a higher error rate. To cover these drawbacks the writers of this paper present an integration of three authentication factors in four echelons; a combination of static passwords, challenge questions, random numbers codes and iris recognition as authentication factors in their algorithm. A major advantage is each authentication factor for each user is synchronised. This implies each authentication tool or device issued by a bank authority is tagged with a user name and password such that in the case of token device loss an impostor will not be able to access a user's account without the corresponding iris template. The schematic representation of this technique is as shown in Figure 2.1.

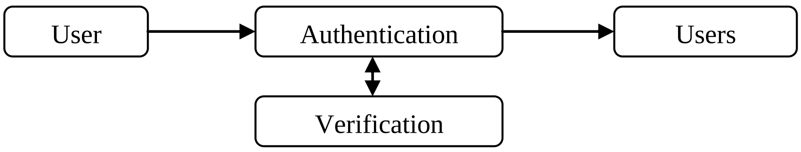

Figure 1: The proposed multifactor authentication scheme

3. Methodology

The proposed Multifactor Authentication Scheme is a solution born from an inherent lack of security of traditional authentication techniques via the Internet. The multi-factor authentication scheme allows a web page to include a validation check using objects embedded in the page. This calls on an interface to activate an Iris recognition device attached to the client's computer, which returns a coded Iris to the server where it is validated alongside with password and user ID, challenge questions and token codes.

3.1 Model Description

A description of the MAS algorithm is:

Registration Phase
A user was enrolled for an Internet bank transaction with assistance of a bank employee by capturing an eye image with an iris recognition device connected to the bank's registration computer system. The user was issued a password for initial login. Users were then required to change the password, then issued a token device. Information personal to a user was recorded and stored in the bank's database to serve as challenge questions.

First Authentication Phase
A user navigated to a page on the secured server through a Web browser and if not logged-in redirected to a log-in page. There, a form with fields prompted a user's ID and password. The user filled in user ID and password then submitted the page to the server for authentication. The web server received the log-in ID and the encrypted password and passed on the user ID and password data to a server-side authentication application. On a successful validation, the user proceeded to the second authentication phase - challenge questions.

Second Authentication Phase

A user was prompted to answer personal pre-registered questions supplied during the registration phase and submit. After a maximum of three attempts, a user was logged out. If a user was successfully authenticated the browser navigated to the third phase for token authentication.

Third Authentication Phase

This phase required the user to supply codes generated from the token issued by the authorising bank. The token was tagged with the user's identity prior to issue; a user was equally subjected to maximum of three attempts at this level.

Fourth Authentication Phase

The final phase of authentication was Iris recognition; a user focused on the Iris recognition device attached to the computer. A live eye image captured by the camera was displayed on the page of the computer. The biometric authentication application fetched the user's iris codes, obtained previously during the registration process from the database and compared it against the live iris codes. Based on success or failure result the browser redirected the user either to a page reporting the failed attempt or to a page where the user carried out the Internet transaction. In failed attempts, the user's account is locked and they were required to consults the bank for account reactivation. Figure 2 shows the structural description of the proposed multifactor model; Figure 3depicts the architectural design.

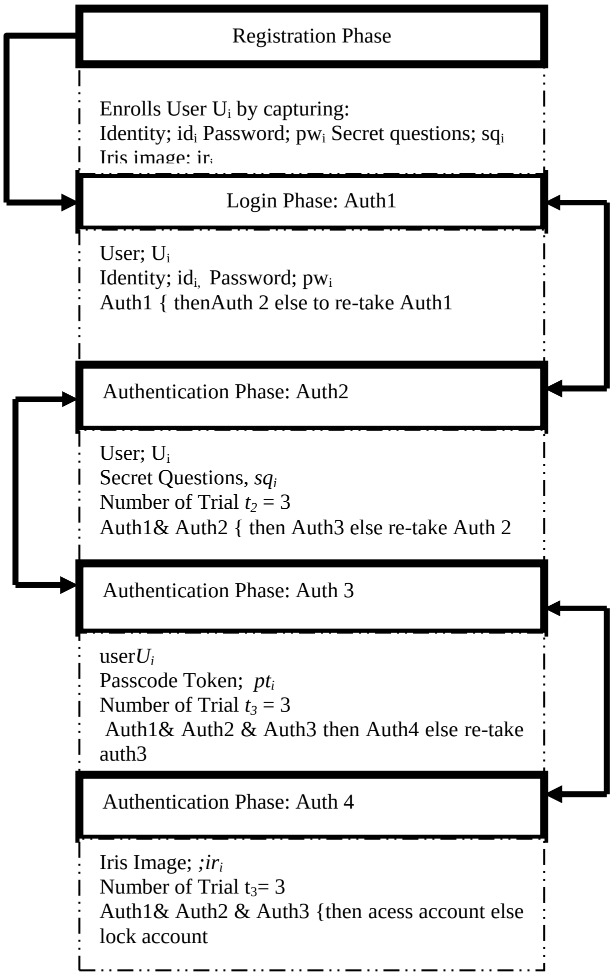

Figure 2: Structural diagram of representation proposed Multifactor Authentication Scheme

3.2 Performance Metrics

Metrics used for performance evaluation include:

False Acceptance Rate (FAR): The ratio of the number of impostor images considered as authentic by the algorithm against the total of impostor images.

$$FAR = \frac{ImpostersClaimAccepted}{TotalImpostClaim} x\ 100\% \quad \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (1)$$

False Rejection Rate (FRR): The ratio of the number of authentic images not considered qualified by the algorithm against total authentic images

$$FRR = \frac{TrueClaimsRejected}{TotalTrueClaims} x\ 100\% \quad \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (2)$$

Equal Error Rate (EER): The point at which FRR and FAR intercepts; used as the threshold point to calculate score distribution.

$$EER = \frac{FAR+FRR}{2} \quad \_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_ (3)$$

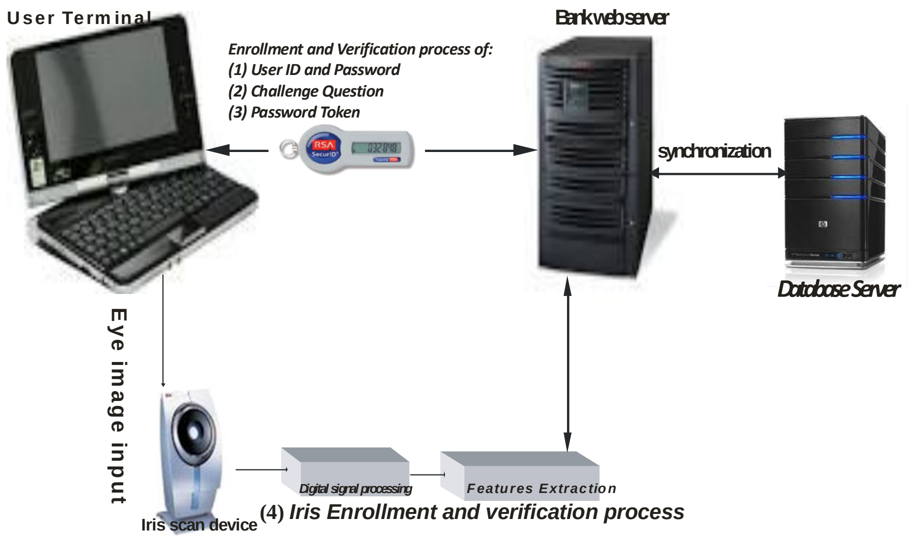

Figure 3: Architectural design of the proposed Multifactor Authentication Scheme

3.3 Data Acquisition

To implement the model, four different datasets were required for each authentication phase. This included passwords, challenge questions, token codes, and iris images. For this research passwords were generated from: http://www.freepasswordgenerator.com/, challenge questions were formulated for each user, eight digits tokens were randomly generated from: http://graphpad.com/quickcalcs/randomN1.cfm while fingerprint and eye images were downloaded from http://biometrics.idealtest.org/; CASIA; Chinese Academy of Sciences - Institute of Automation database. Fingerprint images were used to implement the existing model used for performance evaluation.

4. Experimental Results

In this section experiments were performed on the proposed and the existing schemes in which case the results were evaluated.

4.1 *Proposed Scheme*

Users U001 to U070 were serially enrolled for their passwords, challenge questions, token codes and a pair (left and right) of 70 iris images were enrolled for iris using their respective algorithms. Enrolment process of the iris image involves image pre-processing and feature extraction with a resulting iris codes in form of binary bits stored in the database.

To verify the proposed model for FAR, eighty (80) users were serially verified for the same datasets enrolled. In this case, users U071 to U080 were not part of the earlier enrolled users. Serial matching of each user's input passwords, challenge questions, token codes and iris images was performed with the database. To match iris templates, the Hamming Distances between input iris code and the stored iris code was computed to decide the condition for acceptance or rejection of an iris image as authentic or otherwise. [The Hamming Distance is a measure of the variation between the current iris code and the iris code stored in the database].

Under normal circumstances the algorithm was expected to correctly recognise users U001 to U070 and reject users U071 to U080, which were not enrolled users. However, there are many possible scenarios of impersonations in FAR; of which the following two are considered:

i) Keystroke loggers only.
ii) Keystroke loggers and hardware token theft.

For FRR, users U001 to U070were enrolled and verified using the same procedure in FAR. The algorithm was expected to correctly recognise all users, since only correct users were verified. FRR is said to have occurred in case of any rejection. Figure 4 shows the plotting of the resulting FRR and FAR using common threshold values: 0.00, 0.05, 0.10, 0.23, 0.37, 0.42 and 0.53in both cases.

4.2 *Existing Scheme*

To compare the performance of this scheme a similar experiment was performed with the Singhal *et al* scheme. The model implemented two authentication factors: password and fingerprint biometrics using the algorithm proposed. Users U001 to U070 were serially enrolled for their passwords and a pair (left and right) of 70 fingerprint images. To verify the model for FAR, eighty (80) users were serially verified for the same datasets enrolled. In this case, users U071 to U080 were not part of the earlier enrolled users. Serial matching of each user's input passwords and fingerprint was performed with the database.

Similarly, users U001 to U070 were enrolled and verified for FRR using the same procedure in FAR. The algorithm was expected to correctly recognise all users, since correct users only were verified in this case. FRR is said to have occurred in case of any rejection. Figure 5 shows the plotting of the resulting FRR and FAR.

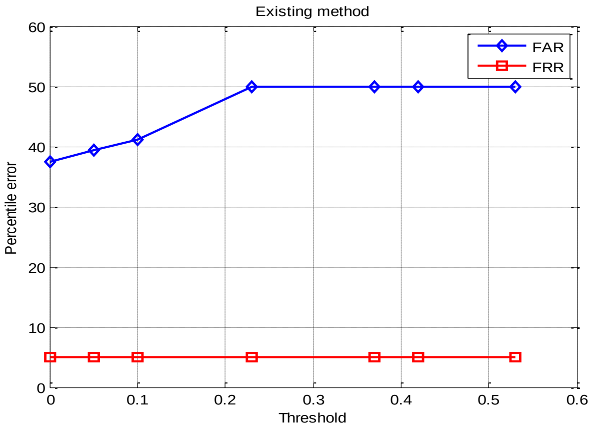

Figure 3: Plot of FAR and FRR of Singhal et al (existing) scheme

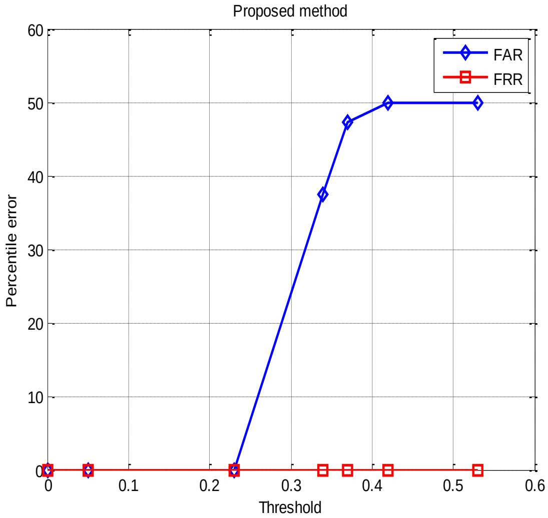

Figure 4: Plot of FAR and FRR of proposed scheme(FAR scenario (i))

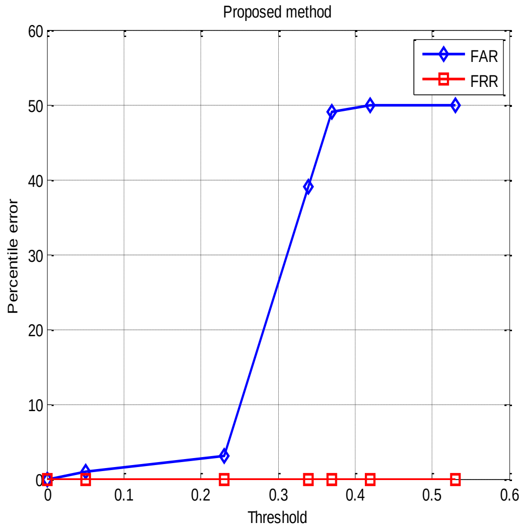

Figure 5: Plot of FAR and FRR of proposed scheme (FAR scenario (ii))

5. Discussion

Figure 3 shows the graphical plotting of FAR and FRR of the Singhal *et al*. scheme. In this scenario, the writers assumed all users' impersonation of password factor for FAR succeeded; the only input data prone to impersonation was the password factor. The system stood a risk of higher vulnerability to impersonation attack compared to the proposed scheme. This degraded the performance of the overall system resulting in 50% of FAR and 5% of FRR. This result implied the system accepted 50% only of all genuine users; 5% of true users were falsely rejected. In other words, the system recorded a 50% and 95% success rate for FAR FRR respectively.

Figure 4 shows results of FAR and FRR of the proposed scheme under scenario (i). This scenario assumes users' computers were compromised for the first two factors: passwords and challenge questions; being the only two inputs capable of being impersonated by key loggers. By analogy, imposters were not in possession of the other two factors: hardware token device and the live eye image of the correct users. In this case, the performance of the system was increased which implied a lower FAR. This was because imposters, which might have tricked the biometric authentication phase, it being the final phase, were rejected at the time the token codes were checked. The experiment showed 0% error rate below 0.23threshold, percentile error, however increased above 0.23.If one considers a threshold of 0.23, a FAR of 0% and 0% FRR is achieved. This implied the system in general accepted 100% of all genuine users; 0% true users were falsely rejected - the system recorded a 100% success rate in each case.

Figure 5 shows the plotting of FAR and FRR of the proposed scheme under scenario (ii). There it was assumed potential impostors were in possession of the correct first three factors: password, challenge questions, and hardware token device with the exception of the live eye image of the original user of the account. Under this condition, the performance of the system was degraded as all impostors succeeded in gaining access to the final authentication phase - iris biometric authentication. This scenario also implied only fingerprint and iris biometrics was accessed in the proposed and existing schemes respectively. Although the result showed a better performance with only 1% and 3% FAR at 0.05 and 0.23 threshold respectively, as opposed 39.39% and 50% FAR in Singhal *et al* scheme. Scenario (ii) however defeated the purpose of our research, and as such, the result was not considered for performance evaluation.

6. Conclusions

This paper describes an alternate scheme to identify individuals for Internet bank transactions using multiple authentication factors.Comparing the simulation results of the proposed scheme with Singhal *et al.* scheme, this implementation served its purpose with a better performance in users' authentication.To this end, the approach presented in this paper provided better insight for entity authentication in Internet banking. Future work may see threat-alerting capabilities considered

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Presenter: This paper is presented by Afolabi Olaitan O.

A Framework for Trust Management in Mobile Ad hoc Ambient Home Network

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Abstract

This research work developed a framework for trust management in mobile ambient home network with a view to secure the home devices and channel against attacks. The proposed framework called mobile ambient social trust consist of mobile ad hoc network to provide network for the home devices, the remote user devices that connect to the home using social network platform through the Internet, the application server that coordinates the activities of the home network and the home services such as communication services, entertainment, home control and home networking. The trust management, global reputation aggregation which considered the direct and indirect communication of home devices and remote devices was employed for device attacks. While real time dynamic source routing protocol was employed for channel attacks to prevent selfish and malicious nodes. The prototype of the framework was implemented using Java 2 mobile edition (J2ME).The framework will enhance the activities in the home by securing the home network against unforeseen network disruption and node misbehavior due to the distributed nature of the environment.

Keywords: *Trust management, framework, ambient home, device attacks, channel attacks*

1 Introduction

The rapid development of mobile computing technology and social network services significantly facilities the communication and resource sharing between mobile users that are socially interconnected with minimum required network infrastructure [1]. Social networks are particularly useful in the scenarios such as driving on a highway, train, cruise or plane which motivates the emergence of mobile ad hoc network (MANET) [5]. MANET is a collection of autonomous nodes that communicates with each other by forming a multi-hop radio network and maintaining connectivity in a decentralized manner [6].

With the context of Ambient Intelligence (AmI), the concept of mobile ad hoc network is likely to play larger roles in the future in which people are surrounded and supported by small context-aware, cooperative and non-obstructive devices that will aid our everyday life [2]. AmI is the capability of an environment populated with electronic devices to exhibit a certain degree of intelligence. To be perceived as intelligence, the whole environment must act in a smart way and this require that each single component in the environment actively coordinates with the others and at the same time is supervised by the rest of the environment so that the whole environment can remain coherent [3].

The main aim of AmI is to enhance the quality of life, offering to users' relevant services such as communication, home control and automation, entertainment and home networking anywhere and at anytime. The nature of AmI home system which is life dependent necessitates the need for securing the home. Attacks in the AmI home can be on the communication channel or on the individual devices [4].
Mobile users' of the social network will be automatically connected to the network based on their profiles, context such as location and social behaviors [5]. Because users of such network do not have any

previous interactions, it is more important to establish an acceptable level of trust relationships among participating users.
Trust is an agent's belief in attributes such as reliability, honesty and competence of the trusted agent [1]. Trust Management is the activities of collecting, encoding, analyzing and presenting evidence relating to competence, honesty, security or dependability with the purpose of making assessment and decisions regarding trust relationships [7].

Previous research work revealed that security is a challenging issue in distributed computer networks as attackers are both inside and outside the network. There is always some vulnerability that can be exploited to break into a system, therefore the need for improvement. This research work seeks to develop a trust management framework called Mobile Ambient Social Trust Model (MAST) for ambient home network. This framework will improve the security of the AmI home by establishing certain level of trust before a new user can be allow to interact with the system.

2 Review of related literature

The review of the existing trust management model for mobile ad hoc network was done with a view to identify the research description, trust factors or methods considered and the obtained results. Some research proposal includes a spontaneous mobile social networks that is fully decentralized and self-managed, context aware Qos frame work, multi-user communication environment by embedding H.323 components, and fuzzy base trust and reputation model for distributed services oriented environment. The trust factor were experience users, inexperience users, similarities of the users profile ,history of friendship, reputation and global convergence time etc. some methods considered were fuzzy trust, smart home network, ubiquitous computing using H.232 components. The objective here is to indentify existing trust management model and how they are related to providing solution to device attacks in the AmI home system. The summary of the review is presented in table 1.

We carried out a review of some related works that focused on mobile ad hoc network routings protocols. We identify some routing protocols with their comparison and performance analysis using factors such as packet delivery ratio, end to end delay, and normalized routing over load etc. This existing protocol was improved upon to proffer solution to channel attacks. Table 1 also presents a summary of the routing protocol with the performance parameters and results.

3 The Conceptual framework for the Ambient Home Network

The Mobile Ambient Social Trust model (MAST) in figure 1 is a hybrid of two networks Mobile Ad hoc Network (MANET) and Social networks. The AmI home is compose mainly of home control server, local and remote home devices and MANET. The home control server contains the applications that coordinate the activities of the home. The MANET is the network used to connect all the mobile devices in the AmI home and remote users within the MANET coverage area. The AmI home is connected to the remote users through the Internet using the social network platform such as facebook, Twitter, Myspace or linkedIn. Through the social network site (SNS), the AmI home would be integrated into the social network.

The home user's devices are protected from attacks using trust reputation aggregation management, while the MANET channel attacks are attended to through trust evaluation routing policy. The reputation evaluation and dissemination system is built to prevent channel attacks such as flooding, jamming, eavesdropping and device attacks such as battery exhaustion and side channel attacks. Users in the AmI home have the privilege of connecting through the customized interface or the general interface. Remote users within the MANET network range and the Internet users are connected to the home through the social network application via the general intelligent interface.

3.1 Trust Management for Device Attacks

The trust management for the device attacks is global reputation of the trust scores. The reputation system for the AmI home has two categories of intelligent interfaces. The customized home application interface that enable users to take advantages of the specific service in the home.

Also, the general home application interface that provide the medium for remote users to have access to all the available services in the home.

The reputation system in figure 2 is developed such that, the home users can acquire their local reputation based on direct connection with the remote users. The summation of the trust score from previous interaction of the remote users with the intermediate nodes and the acquired local trust score is use to build the global reputation.

The remote users are connected to the home user via the Internet. The MANET is use to provide the network for the home users and act as a virtual network for the peer reputation evaluation and dissemination. The reputation system uses Distributed Hash Table (DHT) in figure 3 to store peers trust information because it shortens the data search process and reduces routing complexity.

The DHT is a MANET network with ring architecture to provide fast trust aggregation and secure message transmission. Each peer maintains one table to store the record of communication among the peers. The table stores the remote home peer ID, local weight and the global weight. When performing global reputation aggregation, each peer queries the remote home peers. The local trust values of remote home peers must be equal or greater than the threshold value of the peer under consideration before they can be considered for the computation.

3.2 Trust Management for Channel Attacks

The AmI home network is provided by MANET. The attacks on the communication channel are majorly denial of service which includes flooding, jamming and eavesdropping (Ingrid et al., 2005). The proposed Real Time Dynamic Source Routing (RTDSR) protocol uses the idea of observation based cooperation enforcement in ad hoc network (oceans) protocol and collaborative reputation mechanism built on dynamic source routing (DSR) protocol. The protocol is described with five phases namely: route discovery, route monitoring, data transfer, reputation and timeout phases. The flowchart in figure 4 give detailed description of the various phases in the protocol. The protocol assumed that the ad hoc nodes can authenticate with each other correctly.

4 Prototype of the framework

The framework was implemented using java 2 micro editions (J2ME). J2ME is a program specifically designs for devices with very limited resources such as mobile phones, PDA etc.

The prototype includes some interfaces such as the general interface in figure 6, that allow home and remote users to have access to the various home services, status interface in figure 7 that shows the status of each connected devices, port number setting interface in figure 8 to enter the IP address of the host and the type of protocol used for communication, the customized home interface in figure 9 that give home users easy access to frequently use home applications.

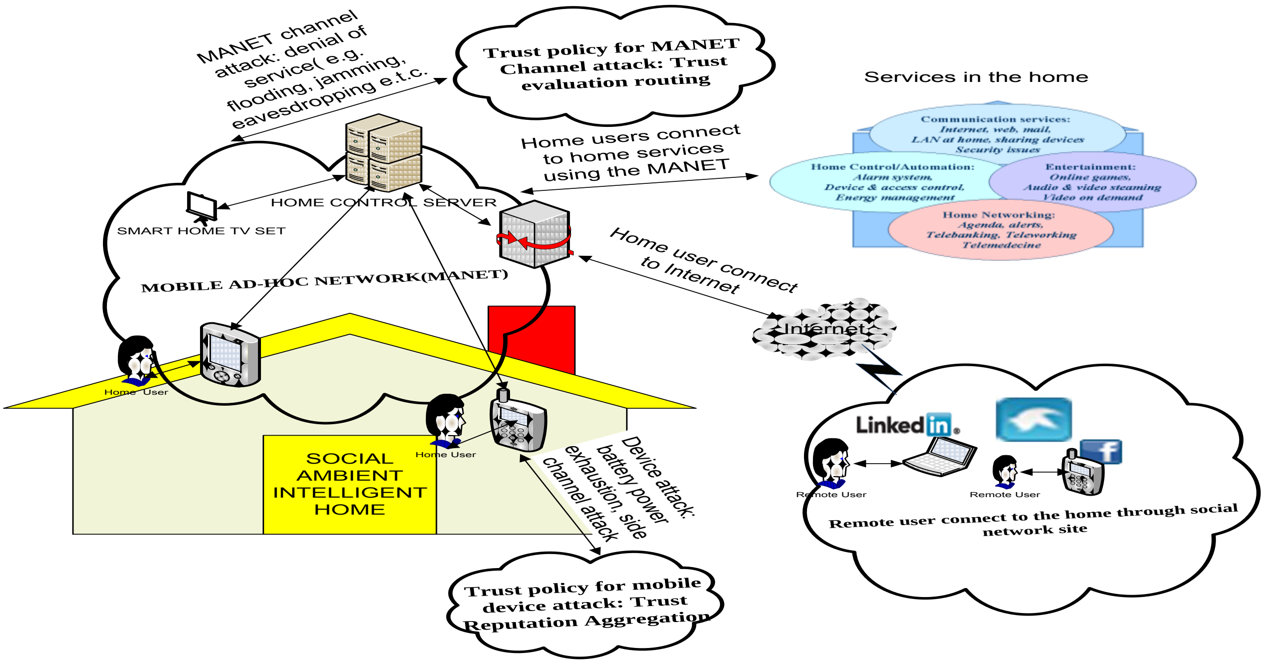

Figure 1: Conceptual framework for the proposed Mobile Ambient Social Trust Model (MAST)

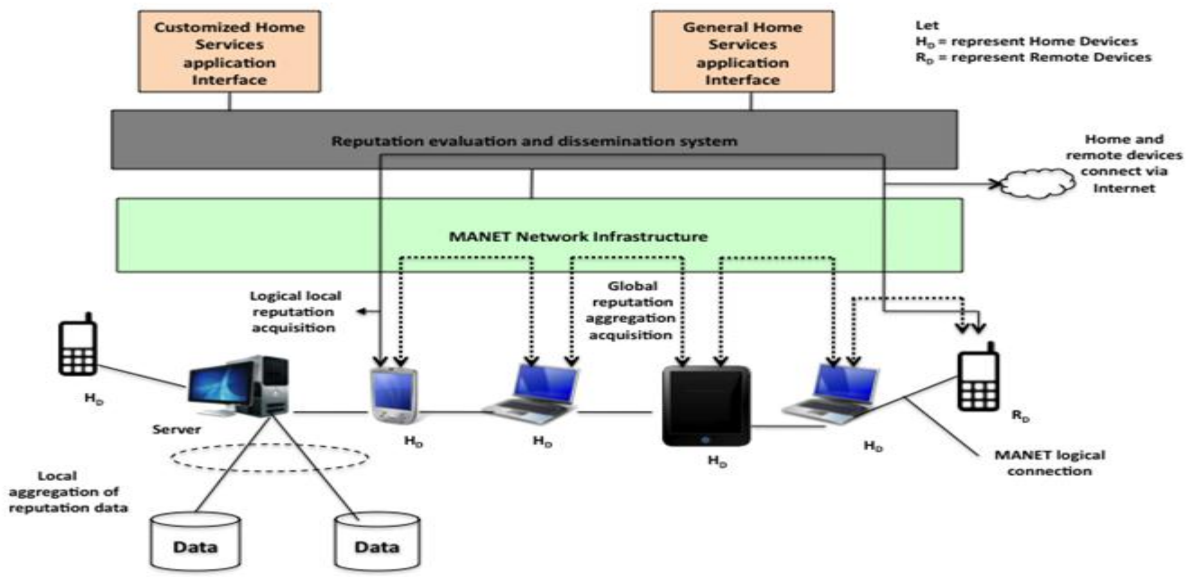

Figure 2: Reputation aggregation system to prevent device attacks

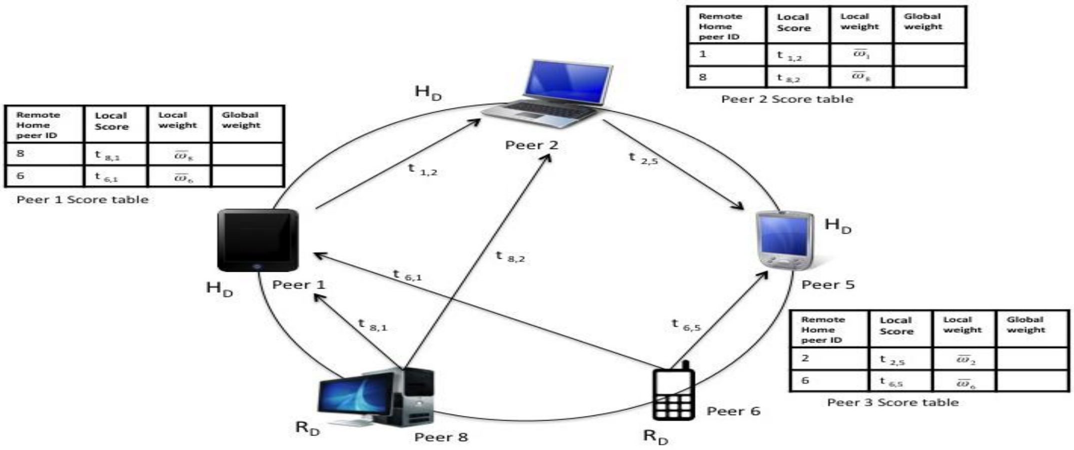

Figure 3: Distributed Hash Table based MANET network

Table 1. Summary of existing trust management models and MANET routing protocols.

Author	Research description	Trust factors /methods considered	Results	Relevance
[5]	Proposed mobile trust, a spontaneous mobile social network that is fully decentralized and self-managed.	i. Experienced user ii. Inexperienced user- similarities of user profile, reputation and history of friendship.	Simulation with dishonest users showed effectiveness of the proposed model	Applied to mobile social network
[14]	A context aware QoS framework was proposed to take advantages of the specific features of the environment.	MANET for large in-home environment e.g. hospital, government building, office and individual building.	Their work was able to address the issue of QoS as related to in-home services and their application	Applied to AmI environment.
[13]	Proposed multi-user communication environment by embedding H.323 components to those of Ambient Intelligence devices.	Ambient intelligence infrastructure developed from ubiquitous computing and communication and intelligence user friendly interfaces.	It offer the advantages of interoperability, flexibility, bandwidth management, security etc.	Applied to AmI devices
[11]	Develop fuzzy logic inference for Internet commerce and online commodity exchanges. The system uses distributed hash table overlay networks to perform fast and secure reputation dissemination among peers.	Global convergence time, malicious peer detection rate, and message overhead.	Fuzzy trust system was compared with Eigen trust system. The fuzzy trust system was able to detect all malicious peers after a few aggregation iterations	Applied to computation of trust and reputation.
[8]	Compare three routing protocol for ad-hoc network. They are Ad hoc On demand Distance Vector (AODV), Dynamic Source Routing (DSR) and Destination- Sequence Distance Vector (DSDV) by varying number of nodes.	End to end delay, dropped packets etc.	AODV and DSR are superior to the DSDV. DSR outperforms AODV in less stressful situation. AODV outperforms DSR in more stressful situation.	The design of the routing protocol must take into consideration the features of the lower layer protocols.

[12]	A reputation system that send packets to only the nodes with high reputation value. Focuses on only selfish nodes.	Reputation based dynamic source routing (RDSR) and compared with the existing dynamic source routing (DSR).	RDSR outperforms normal DSR using metrics: message overhead and throughput.	The model does not consider malicious nodes which is very important

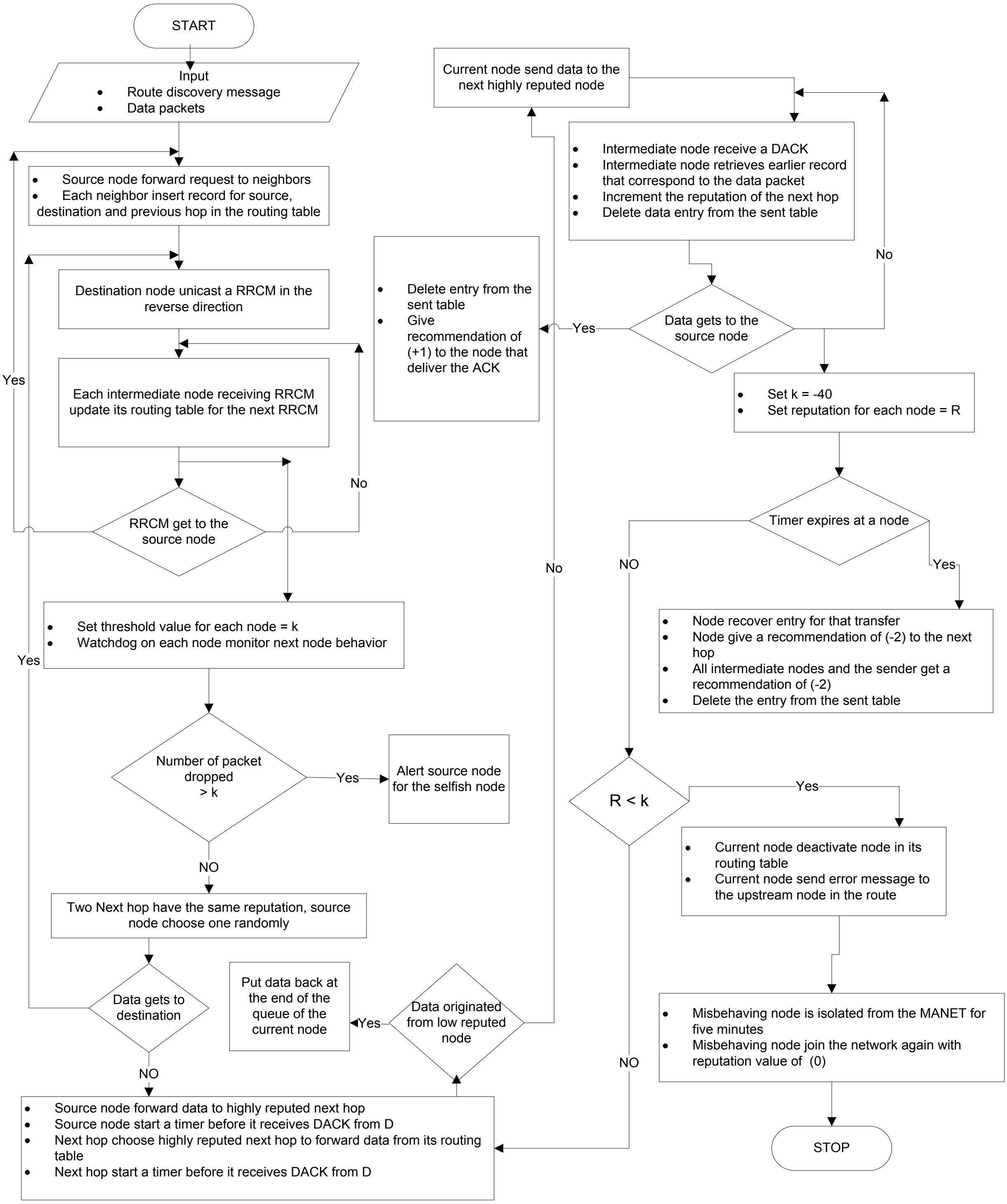

Figure 4: Flowchart for the proposed RTDSR protocol

5 Discussion and conclusion

A framework for trust management in ambient home network was presented to prevent the home against devices and channel attacks. The framework uses global trust reputation aggregation management for the device attacks. The global trust reputation aggregation management considered the direct and indirect communication among local and remote users for trust computation. The channel attacks were addressed using RTDSR protocol. The protocol adopted the idea of Oceans protocol and collaborative reputation mechanism built on DSR protocol. The protocol will prevent both selfish and malicious attacks on the networks. Future work includes the formulation and simulation of mathematical model for the global trust reputation aggregation and simulation of the RTDSR protocol.

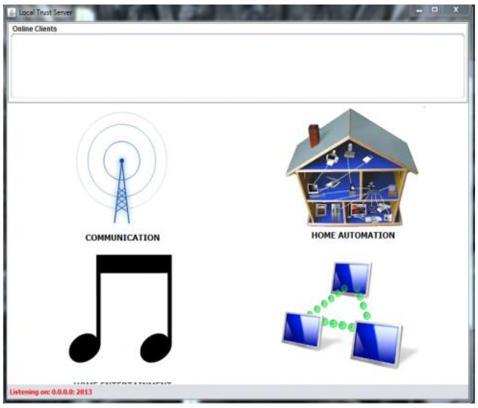

Figure 6: The general interface

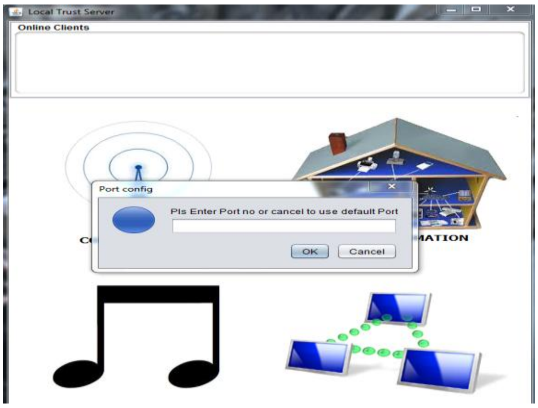

Figure 8 : The port unmber setup interface

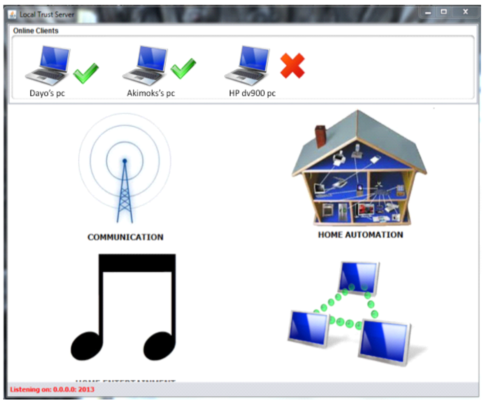

Figure 7: The connection peers status interface

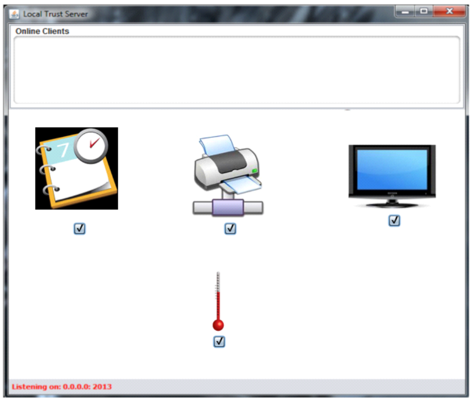

Figure 9: The customized home users interface

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Development of an Improved Intrusion Detection system for Cybersecurity Threats Management

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Abstract

Intrusion detection system is crucial and fundamental to effective cyberspace threats management. This is because modern day cyber threats are sophisticated, complex and dynamic. Emerging threats can spoofed and compromise security policies of a computer network. To overcome this challenge, an intrusion detection system with high detection accuracy and capability to detect novel threats is usually desirable. In this paper, we present an effective and improved intrusion detection system for cyberspace threats management. We propose an ensemble of artificial neural networks using bagging algorithm technique. The proposed ensemble model is simulated using MATLAB 7.8. The evaluation of the proposed model is carried out using a refined version of knowledge discovery data mining intrusion dataset prepared and managed by Lincoln laboratory. The performance of our model is compared with base classifiers made up of different types of artificial neural networks using metrics like: precision, recall and accuracy. Our model performed better.

Keywords: *Intrusion Detection System, Principal component Analysis, Ensemble, Bagging*

1. Introduction

The alarming rate of premeditated attacks with potentially catastrophic effects to interdependent networks and information systems across the globe has demanded that significant attention is paid to critical information infrastructure and networks protection initiatives ([1]; [2]; [3]). This is because the emerging cyber threats are complex, sophisticated and detrimental to global security and socio-economic survivability of a nation [2]. The dynamic natures of these threats make existing solutions to be ad hoc and unable to cope with wide range of cybersecurity challenges. Review of literatures showed that no single entity, be it government, private organisation or individual can address the challenges of cybersecurity in Isolation ([1]; [2]; [3]). What is needed is a system that can detect threats on a large scale network, share the threat information and disseminate cybersecurity advisories to stakeholders in-line with cybersecurity needs expressed by International Telecommunication Union (ITU) [2]. One of the components of the system is an intrusion detection system (IDS).Therefore, IDS is the focus of this study. Among the technologies produced as a result of research efforts in this line are encryption system, firewall, antivirus, antispyware, intrusion detection system and intrusion prevention system ([4]; [5]; [6]; [7]; [8]). There are so many techniques used in the development of these systems. Several authors have used soft computing techniques ranging from Artificial Neural Network (ANN), Fuzzy Logic (FL), agent -based, genetic algorithm to machine learning techniques for modelling threats detection and prevention ([9]; [6]; [3]; [7]; [8]). The usage of these systems has shortcomings like detection accuracy and detection of novel threats. We need to overcome these limitations to a reasonable extent in order to achieve desirable IDS which will be suitable for the proposed model of threats monitoring and information sharing system in our future work. This system will be used for national cyberspace protection. Therefore in this study, we propose an improved intrusion detection system (IDS) which applies ensemble model using bagging algorithm. Finally, we present our research direction and proposed framework for cyberspace threats management

2. Overview of Intrusion Detection System

Intrusion detection system is a software that detects attacks on a network or computer system [10].Intrusion detection systems are normally categorized into misuse detection and anomaly detection. In misuse detection systems, previous attack patterns are stored in a database. Any data similar to this data is classified as attack. Anomaly detection refers to statistical knowledge about normal activity. Intrusions correspond to deviations from the normal activity of the system. The anomaly detection system has high false alarm rate compared to misuse detection systems. However, it is more effective in detecting new attacks or deviation from the nominal usage. Furthermore, the IDS can also be classified based on the data source: Network IDS (NIDS) and Host-based IDS (HIDS) systems. The NIDS analyses data in the network. The HIDS checks for attacks or intrusions in the single host only. It does this by analyzing the audit logs in the system.

3. Related Works

In 1980, the concept of intrusion detection began with Anderson’s seminal paper [10]; he introduced a threat classification model that develops a security monitoring surveillance system based on detecting anomalies in user behaviour. [11] Developed an anomaly based IDS that employed naïve Bayesian network to perform intrusion detection on traffic bursts. [12] Proposed an anomaly based intrusion detection scheme using principal components analysis (PCA), where PCA was applied to reduce the dimensionality of the audit data and arrive at a classifier that is a function of the principal components. [13] Proposed an anomaly based intrusion detection using hidden Markov models that computes the sample likelihood of an observed sequence using the forward or backward algorithm for identifying anomalous. [4] in their proposed model for detecting unknown or novel attack in computer networks. The intrusion detection model which is anomaly in nature was developed using hybrid ANN approach. KDD Cup ’99 dataset and real dataset set were used for evaluating the model. The proposed hybrid ANN model performed better than simple model in terms of detection rate, attack classification, training time and response time. [5] in their own paper addressed problem of effectively classifying intrusion in computer networks, especially in the face of increasing cyber attacks. The authors presented two classification methods involving multilayer perceptron, radial basis function and an ensemble of multilayer perceptron and radial basis function. The analysis of results showed that the performance of the proposed ensemble method is superior to that of single usage of existing classification methods such as multilayer perceptron and radial basis function. [6] Argued that human intervention is still much need in traditional IDS. Traditional IDS can detect intrusion but cannot respond towards it. The paper therefore, analyzed the evolution of IDS and proposed how mobile agent could increase the integrity of the traditional IDS without human intervention. The implementation of the intelligent mobile agent is expected to increase integrity of IDS. [14] In their paper titled “A Detail Analysis of the KDD Cup' 99 Dataset” addressed the problem which affects performance and poor evaluation of IDS through the use of KDD Cup’99 dataset. The authors conducted statistical analysis on the KDD Cup’99 dataset to find the deficiency in terms of redundant intrusion records. Based on the deficiency of the KDD Cup’99 dataset, new NSL-KDD dataset has been proposed. This dataset is an improvement over the KDD Cup’99 as deficiency like redundant intrusion records have been removed so that better performance could be when testing IDS.

4. System Framework

The proposed IDS in this paper has a dimensionality reduction module using Principal Component Analysis (PCA) and a classifier modules. We used two types of classifiers; the ensemble and base classifiers. For the base classifiers, we also used three types of artificial neural networks namely: multilayer perceptron (MLP), radial basis function network (RBF) and generalised regression method

(GRN). The second classifier is the ensemble model which comprises of all the base classifiers. Of course, our aim is to compare the performance of the ensemble model with the base classifiers. The ensemble model is implemented with bagging algorithm for detection of intrusions. The intrusion dataset used in this study is the refined version of the popular and standard intrusion dataset of KDD Cup'99 called NSL-KDD dataset. The classifiers are first trained with the labelled data and later used to detect intrusions of an unlabeled testing data. The results from the base classifiers were compared with ensemble model to determine their performances.

4.1. Dimensionality Reduction

Dimensionality reduction is one of the effective ways of removing redundant data attributes in order to achieve better accuracy in intrusion detection. Effective input attributes selection improves detection accuracy. Irrelevant and redundant attributes of intrusion detection dataset may lead to complex intrusion detection model as well as reduce detection accuracy. The dimensionality reduction in this research is performed by using Principal Component Analysis (PCA).

4.1.1. Principal component analysis

Principal Component Analysis is one of the most widely used dimensionality reduction techniques for data analysis and compression. It is based on transforming a relatively large number of variables into a smaller number of uncorrelated variables by finding a few orthogonal linear combinations of the original variables with the largest variance [15]. In this study, we applied PCA to reduce the dimensionality of the dataset we used so that we can achieve better accuracy and fast training time.

4.2. Classification Methods

Classifier construction is another important challenge in building efficient IDS. The classification accuracy of most existing data mining algorithms needs to be improved as they cannot detect several new attacks. This is because attackers always changing their attack patterns on regularly basis. The classifier will separate the input dataset to two classes: Normal and Anomaly. In this study as earlier discussed we proposed the usage of two model ensemble and base classifiers.

4.2.1. The base classifiers

In this section, we discussed briefly the different types of base classifiers used.

A. Multilayer perceptron (MLP)

MLP is also called feed forward neural network. Multilayer perceptron is a network of perceptron and is used for classification. The neurons are placed in layers with outputs always flowing toward the output layer. This class of networks consists of multiple layers of computational units, usually interconnected in a feed forward way. Each neuron in one layer has directed connections to the neurons of the subsequent layer. In many applications, the units of these networks apply a sigmoid function as an activation function. Multilayer networks [16] use a variety of learning techniques, the most popular being back-propagation.

Normalization formula.

$$Y_{norm} = \frac{Y_{ij} - Y_{min}}{Y_{max} - Y_{min}} \qquad (1)$$

Where Y_{norm} = variable containing normalised input data i.e. A, B , C ………….. AK,
The normalised variables values will fall in range of 0 and 1
$Y_{i\ j}$ = the data being normalised
Y_{min} = the minimum value of the data being normalised
Y_{max} = the maximum value of the data being normalised

$$P_{input} = [A_{ij}\ \ B_{ij}\ \ C_{ij} \dots\dots\dots\dots\dots\dots\dots AK_{ij}\ AL_{ij}\ ] \qquad (2)$$

Where i, $1 \leq i \leq n$, n is the number of records in the data set
J, $1 \leq j \leq m$, m is the number of attributes contained in the data record used in the model
P $_{input}$ = the variable name holding the input dataset for model training
D $_{test}$ = the variable name holding the dataset for model testing

$$T_{target} = [A_{out(1,1)} \ A_{out(1,2)} \ A_{out(1,3)} \ A_{out(1,4)} \ A_{out(1,5)} \ A_{out(1,6)} \ ] \quad (3)$$

$$X_r = W_{1\ r} A_{i\ j} + W_{2\ r}\ B_{i\ j+1} + W_{3\ r}\ C_{i\ j+2} + \cdots \ldots\ldots\ldots\ldots\ldots .. + W_{38\ r}\ AK_{i\ j+38} + W_{39\ r} AL_{i\ j+39} \quad (4)$$

Where i = 1, j = 1 and r is the number of neurons in the rth layer of the ANN
Therefore $X_{1,} \ X_{2,} \ X_{3,} \ldots \ldots \ldots \ldots \ldots .., X_r$ are passed into the transfer function chosen for the detection model

$$f(X_r) = \frac{2}{\{1+\exp(-X_r)\}^{-1}} \quad (5)$$

where r starts from 1 and is the number of neurons in the hidden layer

$$Y_r = f(X_r) \quad (6)$$

We can then have $Y_{1,} \ Y_{2,} \ Y_{3,} \ldots \ldots \ldots \ldots \ldots Y_r$ which are the outputs from the neurons in the hidden layer.
These outputs from the neurons in the hidden layer will serve as inputs to the neurons in the output layer of the ANN model

$$X_r^2 = Y_1 W_1^2 + Y_2 W_2^2 + Y_3 W_3^2 + \cdots \ldots\ldots\ldots\ldots\ldots + Y_r W_r^2 \quad (7)$$

This equation can be rewritten as

$$X_r^2 = \sum_{r=1}^{k} (W_r^2 \ Y_r) \quad (8)$$

The sum of product of input and the connection weight at the hidden layer is also passed into the transfer function of the output neurons as in equation

$$A_r^c = f(X_r^2) = \frac{2}{\{\ 1+\exp(\ -X_r^2\ )\}^{-1}} \quad (9)$$

Where r, $1 \leq r \ \leq k$

The error E between the observed and the estimated attack pattern is computed as

$$E = {}^1/_2 \sum_{i=1}^{n} [A_{out(i)} - \ A_{r(i)}^c]^2 \quad (10)$$

Where n = number of records in the training dataset
The update of weight in all iteration is carried out using

$$\Delta W_{(i\ j)} = -\alpha \frac{\delta E}{\delta E_{(i\ j)}} \quad (11)$$

B. Radial basis function network (RBF)

Radial basis functions have been used and applied in area of neural networks where they are used as a replacement for the sigmoidal transfer function. Such networks have three layers; the input layer, hidden layer with RBF non-linearity and a linear output. The most popular choice of the non-linearity is the Gaussian. Radial basis networks can require more neurons than standard feedforward back-propagation networks, but often they can be designed in a fraction of the time it takes to train standard feedforward networks [17].

C. Generalised regression method (GRN)
Generalized regression method (GRN) is a kind of radial basis network often used for function approximation. It returns a new generalized regression neural network which can be designed quickly. The larger the spread, the smoother the function approximation. To fit data very closely, we used a spread smaller than the typical distance between input vectors.

4.2.2. Ensemble model

Ensemble learning is the process by which multiple models, such as classifiers or experts, are strategically generated and combined to solve a particular computational intelligence problem. Ensemble learning is primarily used to improve the classification, prediction and function approximation performance of a model. It is also used to reduce the likelihood of an unfortunate selection of a poor model. There are different methods of implementing ensemble learning. They include bagging, boosting, adaBoosting etc. For this study, we used the popular bagging technique because of its simple in usage and accuracy in predicting results.

4.2.3. The Bagging algorithm

Bagging [18] is a ‘‘bootstrap’’ ensemble method that creates individuals for its ensemble by training each classifier on a random redistribution of the training set. Each classifier’s training set is generated by randomly drawing with replacement, t, N examples. where N is the size of the original training set; many of the original examples may be repeated in the resulting training set while others may be left out. Each individual classifier in the ensemble is generated with a different random sampling of the training set. The procedure for hybrid modelling is as used by [5] in their paper. Given a set, D, of d tuples, bagging works as follows; for iteration i (i =1, 2... k), a training set, Di, of tuples is sampled with replacement from the original set of tuples, D. Note that the term bagging stands for bootstrap aggregation. Each training set is a bootstrap sample. Because sampling with replacement is used, some of the original tuples of D may not be included in Di, whereas others occur more than once. A classifier model, Mi , is learned for each training set, Di. To classify an unknown tuple, X, each classifier, Mi, returns its class prediction, which counts as one vote. The bagged classifier, M*, counts the votes and assigns the class with the most votes to X. Bagging can be applied to the prediction of continuous values by taking the average value of each prediction for a given test tuple. The bagged classifier often has significantly greater accuracy than a single classifier derived from D, the original training data. It will not be considerably worse and is more robust to the effects of noisy data. The increased accuracy occurs because the composite model reduces the variance of the individual classifiers. For prediction, it was theoretically proven that a bagged predictor will always have improved accuracy over a single predictor derived from D.

4.3. Description of Dataset used in the Study

The intrusion data used in this study is NSL-KDD. This intrusion data is the refined version of KDD cup’99. The advantage of this dataset is that all the redundancies of the KDD Cup’99 dataset have been removed. By so doing, performance evaluation of models are improved. It is based on this advantage that we have decided to use the dataset as against KDD Cup’99. NSL-KDD has all the attributes and features of KDD Cup’99 dataset, it also has both training and test sets. The sample version of the dataset has 65,535 connection records for training and testing dataset. Each data sample in KDD Cup’99 dataset represents attribute value of a class in the network data flow, and each class is labelled either as normal or as an attack. In total, 41 features are in NSL-KDD just like KDD Cup’99 dataset [14] and each connection can be categorized into five main classes (normal class and anomaly classes (DOS, Probe, U2R, and R2L)). The input attributes in NSL-KDD dataset for each network connection that have either discrete or continuous values can be divided into three groups.

5. Experimental Design

In this study, two models were implemented; the ensemble model and the base classifiers (MLP, RBF and GRN). The dimensionality reduction process conducted using principal component analysis was applied to both models in order to get the required input for the model. By so doing, redundancies and irrelevant attributes that do not contribute any significant value to the dataset classification were removed. Our aim in this study is to solve a multi class problem. Here, five classes case is described. An output layer with five neurons (output states) was used: [1 0 0 0 0] for normal conditions, [0 1 0 0 0] for DoS, [0 0 1 0 0] for R2L, [0 0 0 1 0] for probe and [0 0 0 0 1] for U2R. The desired output vectors used in training and testing phases are simply as mentioned above. The desire outputs apply to both models i.e. ensemble and base classifiers. MATLAB toolboxes which contain ANN, RBF, GRN and ensemble functions were used for the model implementation. The implementation of the neural networks using appropriate MATLAB toolboxes make it possible for one to define specifications like number of layers, number of neurons in each layer, activation functions of neurons in different layers, and number of training epochs. Then the training feature vectors and the corresponding desired outputs can be fed to the neural network to begin training. All the implemented neural networks (MLP, RBF and GRN) had input neurons equal to the result of dimension produced by the principal component analysis which is 17 features and five output neurons equal to the number of classes in the dataset. We arrived at 17 features or attributes because we instructed the principal component analysis to eliminate features that contributed less than 2% to the variance of the dataset. The number of hidden layers and neurons in each network were parameters used for the optimization of the architecture of the neural network. Error back-propagation algorithm was used for training MLP and appropriate spread function was used for the RBF and GRN.

5.1. Experimental results, performance evaluation and discussion

The training dataset was used to train all the models so that they could learn. In the testing phase, the testing dataset were randomly selected from different categories and were given to the model for classification. The obtained results were then used to compute overall accuracy of the proposed systems. The overall accuracy of the proposed system was computed based on the definitions, namely; precision, recall and accuracy which are normally used to estimate the class prediction. The performance evaluations of the models were carried out using the following metrics:

1. Precision = $\frac{TP}{TP+FP}$ (12)
2. Recall = $\frac{TP}{TP+FN}$ (13)
3. $Accuracy = \frac{TP+TN}{TP+TN+FN+FP}$ (14)

TP = True positive
TN = True negative
FN = False negative
FP = False positive

Table 1: Performance comparison of MLP, GRN, RBN and Ensemble models with randomly selected dataset

Method	Training			Test		
	Precision	Recall	Accuracy	Precision	Recall	Accuracy
MLP	0.70	0.98	0.70	0.96	0.98	0.94
GRN	0.92	0.99	0.91	0.56	0.75	0.61
RBF	0.84	0.99	0.84	0.49	0.65	0.54
Ensemble	0.82	0.99	0.82	0.70	0.80	0.70

Table 2: Performance comparison of MLP, GRN and Ensemble models with randomly selected dataset t

Method	Training			Test		
	Precision	Recall	Accuracy	Precision	Recall	Accuracy
MLP	0.92	0.99	0.92	0.96	0.98	0.94
GRN	0.98	0.97	0.98	0.59	0.75	0.65
Ensemble	0.95	0.98	0.97	0.78	0.86	0.79

Table 3: Performance comparison of MLP, RBN and Ensemble models with randomly selected dataset

Method	Training			Test		
	Precision	Recall	Accuracy	Precision	Recall	Accuracy
MLP	0.70	0.92	0.69	0.96	0.98	0.94
RBF	0.84	0.99	0.84	0.56	0.61	0.53
Ensemble	0.78	0.96	0.78	0.76	0.79	0.74

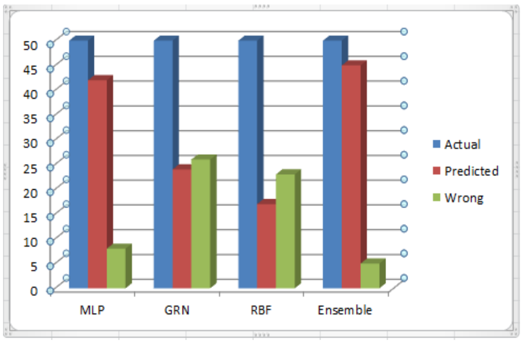

Figure 1: Ensemble Vs the 3 Classifiers

Figure 2: Ensemble Vs 2 base classifiers

The results of our experiment from tables 1 – 3 showed that MLP is very good in detecting new dataset while the RBF and GRN are good at recognizing known data pattern. This is the reason why they have good accuracy and precision when training dataset was applied to test them. The accuracy of MLP was not as good as theirs when training dataset was used to test it. Therefore, the performance of our proposed ensemble model was affected when new data were exposed to it because RBF and GRN are very poor at classifying new dataset. Based on this observation, we tried to combine MLP and RBF for ensemble and we also did same for MLR and GRN. We discovered that performance of ensemble model improved considerably with these combinations better than when the three models were combined for the ensemble model. However, the combination of MLR and GRN ensemble performed better than the MLR and RBF ensemble. Base on this, the combination of MLP and GRN for ensemble has the best performance. Figures1 and 2 also showed performances of the models when test data were applied to ensemble model of three classifiers and two classifiers.

6. Conclusion

The paper described a network IDS framework that is a combination of Principal Component Analysis algorithm with base classifiers (MLP, RBF and GRN) and ensemble model which is the combination of all the classifiers. The framework built the patterns of the network over datasets labelled in NSL-KDD data set. With the built patterns, the framework detects attacks in the datasets using the base classifiers and ensemble methods. The ensemble model achieved higher detection rate and reliability than the base classifiers most of the time. However, the ensemble of MLP and GRN performed better than the ensemble of the three classifiers. This is because RBF does not perform well when exposed to new dataset. It is also too slow during training. These shortcomings put RBF at disadvantage. In order to achieve better performance we removed the RBF from the ensemble model and test with test dataset. Better accuracy was achieved. However, the predictions of both the ensemble model and base classifiers were very poor in classifying some categories of attacks in the dataset used. This is because of their few patterns in the dataset used. This posed some limitations to this work. We shall like to continue our work in this direction in order to build an efficient intrusion detection model with other intrusion detection dataset and more techniques will also be explored to determine best combination of classifiers for our proposed ensemble model. Effort will be made in the future to test our model with network real life data. From the Experimental results obtained, we concluded that ensemble method performed better than the base classifiers and that it will suitable for modelling threats detection component of our proposed cybersecurity threats monitoring and information dissemination model in our future study.

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Innovative ICT and/or Engineering Approaches

Learning Skills for Distributed Engineering Design

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Abstract

Modern industry takes advantage of geographically distributed engineering design teams whose work is based on digitally mediated communication. Versatile resources, cultural experiences and skills can be put together in order to solve challenging engineering problems more innovatively and faster. However, the teaching of engineering design skills is often founded on the assumption that engineers are still working in a single design department. Students still learn technical skills, but there is a risk that their teamwork and networking skills do not meet the requirements of industry. This paper presents a new learning space called Future Design Office (FDO) that is under development at Turku University of Applied Sciences, demonstrates why and how it was created and illustrates its physical and virtual design environments. A further aim of the paper is to discuss with other institutions that are modifying their engineering design courses to address the challenges of the distributed team-based design.

Keywords: *Design engineering education, Distributed design, Design knowledge, Digital product process, Cross-disciplinary teamwork skills*

1. Introduction

Products and services become more and more complex and because of competitive pressure they have to be developed in a limited time scale. In international companies, geographically distributed engineering design offers the potential for enhancing product development with reduced time to market and improved efficiency. However, collaborative design resources and streamlined design processes are needed to share a common goal, apply wide knowledge and contribute to design from various perspectives. In a distributed design environment, people have limited possibilities of direct cooperation, which makes problem-solving more difficult and requires new types of knowledge and skills.

Traditionally, the role of education has been to give knowledge-based readiness, which later would be applied in working life. However, developing new products, services and organizational or social innovations requires competencies, which are impossible to learn in theory only. Watts et al. [1] present the individual, communal and networking innovation competencies necessary for students to succeed in the workplace. These competencies are, for example, independent thinking and decision-making, creative problem solving, the ability to co-operate in a diversified team or working community, the ability to combine knowledge and methods of different fields, the ability to work in networks, and the ability to co-operate in a cross-disciplinary and multi-cultural environment. This means that besides the technical readiness of engineering students, the social aspects of working have to be emphasised as well.

Various studies [2, 3, 4] are conducted from the technology, communication and education viewpoints on distributed engineering design. As a fast developing domain, there is an extensive need to better understand the learning environments in which students can apply their theoretical design knowledge in practice and achieve the required skills for working in a distributed design context. At Turku University of Applied Sciences (TUAS), as part of mechanical and production engineering studies, special attention is paid to enhance students' design skills needed in today's distributed engineering environments of industry. The Future Design Office (FDO) effort is part of the comprehensive development of innovation pedagogy [5, 6, 7] at TUAS. Innovation pedagogy is a learning approach that defines in a new way how knowledge is assimilated, produced and used in a manner that can create innovations.

This paper discusses the FDO concept under development at TUAS. It describes a learning environment in which engineers can work effectively in distributed design teams across geographical, cultural and professional boundaries, and gives reasons why the FDO learning space is needed and how it will be created. The aim of the paper is also to share experiences with other engineering education institutions that are developing their engineering design courses to meet the challenges of distributed global design. The second section of this paper introduces the fundamentals of distributed engineering design and describes the complexity of a design process in modern industry. The third section forms a theoretical framework for the curriculum development by formulating a connective path around engineering design knowledge and the product development process. This framework leads to identifying the most essential learning objects of engineering design. The fourth section describes the structure and contents of the planned studies for generating skill for distributed design. The physical and virtual learning environments are introduced as well. Finally, the lessons learned so far are reviewed.

2. Modern engineering design

Products and services are more and more complex and their use environments are increasingly global, mobile and virtual. The design problem is always unique and specific, and thus design knowledge must be translated to support the specific case. The engineering design process can be seen as a knowledge transformation process from an idea to a (technical) system, and the system is formed within the limits of the designers' (all peoples involved) cognitive and information capacities [8]. In the engineering design process, knowledge is used for creating new artefacts or improving the existing ones. This process is at the focus of design science that aims to develop knowledge for the design (process) and for realisation (implementing), and for the utility evaluation of the artefact [9]. Because the products are mainly designed for the global markets the design knowledge behind them also has to be globally relevant.

Extensive research and development works have been conducted on distributed engineering design, and a lot of enabling technologies developed for the team communication and information sharing in the design process, such as in Chandrasegaran et al. [10] and Jin [11]. Web-based services are widely considered the best solution for process and design information integration. Typically, they offer distributed services that provide engineering applications and tools on the web. A highly flexible software architecture had been developed, including engineering tools for computer-aided design (CAD), computer-aided engineering (CAE), product data management (PDM), product life cycle management (PLM), optimisation, cost modelling, etc. Learning skills for engineering design is nowadays learning of these software tools and cooperative processes to utilise them. This is especially important when distributed design is in question.

2.1. Complexity of the distributed design process

Design teams no longer work in the same place at the same time. The shift from collocated working to distributed working has significantly increased the complexity of design work. Geographical dispersion influences working practices and the needs of communication and coordination because the physical distance of workers hinders natural face-to-face communication. In a distributed environment, designers have limited possibilities of direct cooperation, which makes problem solving difficult [12]. Besides geographical dispersion, the distributed design team also often faces many other complexity factors of working, such as asynchronous working time, diversity of actors, temporary organisational structures and information and communication technology (ICT) mediated interaction [13].

However, distributed ICT mediated working offers a valuable means to bring together geographically and temporally dispersed design team members to work on common tasks. They share a common goal and contribute in order to reach it by applying their diverse knowledge and perspectives. Solutions are based on technical problem solving criteria as well as negotiations between designers' different perspectives. In distributed design, each designer or design team has their own goals and tasks to perform. However, they need to coordinate effectively with other designers, because of interdependencies between the tasks of the entire design project. Managing task interdependencies and designers' multiple perspectives are the most central challenges in distributed design [12]. Distributed ICT mediated design can be performed in two modes: working at the same time (synchronous working) and working at different times (asynchronous working). These modes are supported by various information, communication and collaboration technologies.

Cross-functional teamwork in product development has been studied by various authors. The study by Owens [14] shows that delay in product development projects is mainly due to poor understanding of customer requirements, insufficient knowledge about the product's technology and market forces. This indicates that poor internal communication between functions or team members makes it difficult to define product or service requirements and develop design specifications. Thus, three essential cooperative processes of design work are: (1) coordination processes in order to manage task interdependencies, (2) establishment of common ground and (3) negotiation mechanisms in order to manage multiple perspectives in design [12].

The sources of information to meet all product requirements can be, for example, users, distributors, manufacturers or authorities. Besides the technological needs, the environmental dynamic factors, users' psychosocial needs and the functional purposes of products are important sources of knowledge for the desirable products. The more deeply designers understand users and the use context of a product or a service, the more they are able to discover the needs of customers. This means they fulfil the explicit technical requirements, but most importantly the tacit requirements of users caused by dynamic changes in the use environment. This systems approach gives a broad pre-understanding about the problem backgrounds and alternative solutions. The first paradigm of the product development process was 'technology centred', the second wave was 'user centred', and the present can be named 'systems centred'. The paradigm shift means that the design team needs a holistic view about the problem and solution space.

2.2. Learning theoretical and practical skills

According to innovation research, knowledge and skills of knowledge application play a crucial role when creating new services, products and organisational or social innovations. Group processes where learning happens in cross-disciplinary teams form an essential part of the whole process of learning. Therefore, an ideal learning space supports the application of theoretical knowledge in practice in cross-disciplinary team work [15]. We need to consider learning spaces to avoid gaps between theoretical knowledge and real problem solving skills required in working life.

Design knowledge represents the students' theoretical knowledge base about the engineering design they are learning during their studies. Design knowledge is composed of understanding theories (e.g. the strength of materials), constructs (e.g. threshold value), tools (e.g. CAD system), processes (e.g. stage-gate process in product development) and various methods applied in the product development phase [9]. In engineering design, computational and mathematical methods are frequently used to evaluate the quality and effectiveness of products, while experiments and field tests are also important empirical methods. Besides the knowledge, the findings of Ahmed and Wallace [16] suggest that novice designers also require support in identifying what they need to know.

Wodehouse et al. [4] presented a framework for teaching engineering in a global context using a range of technologies to support design teams' collaborative work. They found that students and teachers have to overcome technological, pedagogical and cultural issues for successful learning. For instance, in global projects, each site prefers their own chosen or developed technologies, for cultural and practical reasons. Therefore, ice breaker exercises for team work and effective project management activities are required.

In working life the way of working includes that problems are solved and innovations are created in groups and networks. Traditionally, the role of education has been to give knowledge-based readiness, which later would be applied in practice in working life. Professional development requires both theory and applying skills [17]. Applying the skills of graduates is perhaps weak, as educational research has noted the transfer problem where learning cannot often be recalled and applied in working life [18]. The learning in one type of setting is not accessible when the learner is moved to another context. This problem can be, at least in part, avoided by creating identical elements in education and working life.

3. Study context and methods

The physical environment for FDO development is the Machine Technology Centre Turku Ltd (MTC), established by the City of Turku together with approximately 80 companies. Its mission is to offer local metal and mechanical engineering companies an environment to develop and test state-of-the-art production technology prior to full-scale production or machinery investments. In pursuit of this, the education institutes in the area, such as TUAS, Turku Vocational Institute, and the Turku Vocational Adult Education Centre, are offering their students a modern learning environment. Besides the studies and practical training with machines, students, teachers and researchers at MTC are participating in R&D projects driven by the companies. These projects can range from minor problem solving to large research programmes funded by an external public source.

MTC has a wide range of production machines (Figure 1), but the design process for the products and the digital transfer of the product information have not been fully integrated into the machinery there. When we consider a modern digital product process from the feasibility study to the recycling of a product, currently only the middle part of the process is covered at MTC. Therefore, students have had no opportunity to learn the entire digital product process by utilising the computer aided technologies seamlessly. This is the main motivation behind the FDO development.

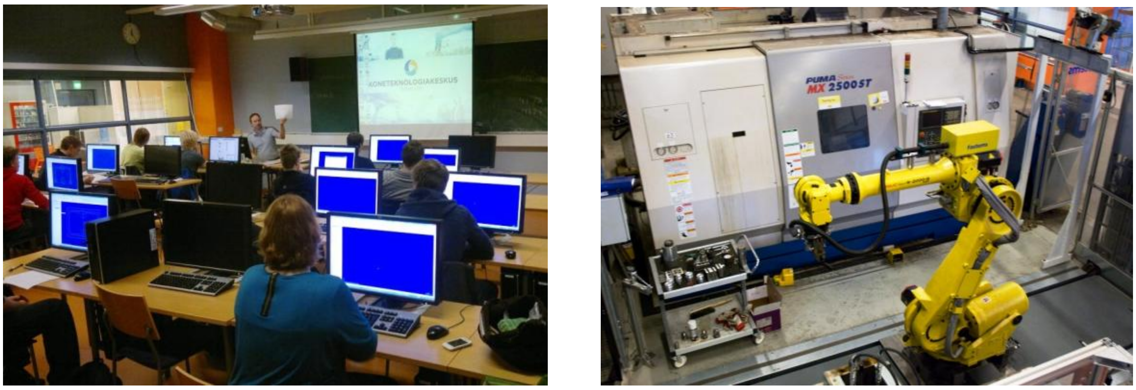

Figure 1. Conventional class room (CAD) and robotized CNC cell in MTC.

The first step in the project was to find the theoretical basis for the new learning and teaching approach that aims to enhance engineering students' distributed design skills, but also supports the learning of engineering fundamentals. In order to achieve these aims, we selected Järvinen's [19] systems development model as a framework that covers the entire engineering design process. The systems (e.g. product) development consists of the following stages: (1) construct a conceptual framework, (2) develop system architecture, (3) analyse and design the system, (4) build the system, and (5) observe and evaluate the system. Each stage is designed to gather information and perform all the tasks necessary to progress in the design project. Between the stages there are entry gates or decision points where the results of the actions of the previous stages are reviewed and the quality is checked.

Secondly, the idea of the FDO was introduced to the local company partners within a regular joint seminar and companies were asked to commit to offering design problems as customers for the students. The solutions for the authentic problems are the contributions of every engineering design. Solutions are assessed as they are applicable by users or customers in a specific environment. When design activity is authentic and framed in user or customer needs it ensures the relevance of engineering design.

Thirdly, after the first six months of basic planning, the project group specified the learning objectives and courses for the FDO students based on the existing curriculum of the degree programme of Mechanical and Production Engineering. The FDO concept and subjects of learning were then discussed with the teachers, researchers and other personnel in the degree programme, after that the FDO concept and implementation plan was announced.

The fourth step was to plan physical and virtual learning spaces. Furnishing of the new learning space started immediately after the plan was agreed, and the first design teams were already working in the unfinished FDO environment with their summer projects. Construction of the virtual learning environment started by implementing a web-hosted product data management (PDM) system to improve learning in the distributed design. It provides a knowledge base for students to create, store, share, use and reuse design information in team-based design projects locally and with the collaborating institutions.

The final step in the FDO planning will be the starting of the first course in the autumn of 2013. A maximum of 15 students will be selected on the basis of their interest, study performance and work experience. There is an unlimited enrolment from all specialisation programmes and year levels, and even students from other degree programmes that include design courses, such as degree programmes in Automotive and Transportation engineering and Industrial Design can apply.

4. Study plan for the Future Design Office students

The curriculum for the degree programme of Mechanical and Production Engineering describes the structure and contents of studies that are planned in close co-operation with working life. Students can choose specialisation areas from the following four: Product Development Engineering, Production Engineering, Energy technology or Marine technology. These four specialisation areas are structured to share a common core of engineering courses. Due to the industrial structure surrounding the faculty, there is external pressure on our engineering students, in addition to their core engineering competencies, to be able to cooperate internationally with good language and presentation skills. Additionally, the industry also expects graduates are able to contribute to innovations and be open and broad-minded when performing their engineering tasks in working life.

A Bachelor of Engineering specialising in Product Development Engineering will be an expert in planning, design, and product development, and s/he develops mechanical products and services in a customer-oriented way together with sales and production personnel. A product development engineer typically finds employment in the design and development department of an industrial enterprise or in an engineering office where s/he has the tasks of an expert, and with increasing experience, duties in the project management. It is also possible to specialise in tasks within production or sales because design engineers work in cooperation with these sectors. The studies furnish engineering students with solid theoretical mechanical engineering knowledge and competence in computer-aided design (CAD) as well as understanding about materials technology and manufacturing techniques. In addition, product development requires a customer-oriented approach, teamwork skills, creativity, project management, and language skills.

The curriculum is the same for the students who are learning in an FDO environment as for other students, but the principle of implementation is different. As many courses as possible are integrated with the industry-origin design tasks. Integration of courses prepares students with engineering problems in practice better. Basic studies and professional studies can also be integrated. Mathematics, physics and chemistry, project management and foreign language courses can be easily integrated with professional studies in the design project environment. When the industry origin projects are not enough students learn with conventional exercises prepared by teachers. However, to ensure that enough projects from industry are available, some local companies are asked to commit design problems that can be joined to the aims of engineering courses. Table 1 depicts the selected courses for product development engineering and how they are linked to the product development process and what types of software tools are in use (commercial brands are not advertised).

Table 1. Courses linked to a product development process and applied software tools in FDO learning environment.

Stage of product development process	Related course & ECTS credits	Software tool	Description of learning objectives
Construct a conceptual framework	Product development (15)	Databases (e.g. patents), Visualisation tools.	Team-based working, information collection and idea generation.
Develop a system architecture	Product development (15)	Diagram, Flowchart, System design	Building a logical description of system and rough prototypes.
Design and analyse the system	3D-Modeling (5), Mechanical drawing (6), Strength of materials (8), CAE/FEM (6), Mechanical design (15), Materials (5), Industrial design (15)	CAD, PDM, CAE, FEM	Computer-aided design and modelling. Creating product structure by product data management system. Running simulations using the model. Finite element analysis.
Build the system	Design for manufacturing (5), Manufacturing technique & industrial safety (5)	CAM, Offline programming tools, CMM, ERP	Production of components based on CAD models, quality inspections, learning by doing.
Observe and evaluate the system	Product development project work (15)	Project management tools	Integration of the entire product development process, the outcome receives feedback from authentic customers.

At the beginning of studies, the design problems are limited to the mechanical component level, but when students gain more experience they will get wider open-ended product development works. While learning the practical subjects of engineering in the FDO environment they use cross-disciplinary knowledge and team work to qualify. During the product development project students learn the preparation of project proposals including the identification of design objectives and constraints, generation and evaluation of potential approaches, selection of the most promising design concept and architecture, identification of product structures, and assignment of responsibilities to team members. After a customer approves the plan, the design process will comprise preliminary design, followed by detailed design and simulations, prototyping and testing, and preparation of a final design report. Progress is evaluated frequently with the customer, culminating in prototype demonstrations and design reviews at the customer's premises.

4.1. Learning environment model for distributed design

The above described study programme resembles typical product development engineering studies, but it is implemented in a different way in order to learn skills for distributed engineering design. The fundamental difference with conventional studies arises from three principles: (1) all the courses are linked to the continuous product development process; (2) all essential design material is digitally created, transferred and used through the product process; and (3) design work is done in ICT mediated cross-disciplinary teams. These principles are applied as much as possible during the studies.

The conceptual model of the FDO learning environment is described in Figure 2. FDO is an integrated part of MTC and there is a wide range of production machines covering laser cutting, punching, bending, milling and advanced welding methods. A flexible manufacturing system (FMS) allows the production of small series and advanced components. The aim is to integrate the engineering design process completely into this machinery by means of CAD/CAM technology, CNC machines and off-line programming and simulation of machines and robots. Integration of design, manufacturing and inspection is also possible by means of digital CMM (coordinate measuring machine) where designers can create CMM programs directly from a CAD file. When a CMM is digitally integrated into a CAD system, students can learn tolerance design effectively in a concrete way. A cloud hosted product data management (PDM) system is an essential part for learning distributed design skills. It provides a knowledge base for students to create, store, share, use and reuse design information in team-based design projects locally and with the collaborating institutions.

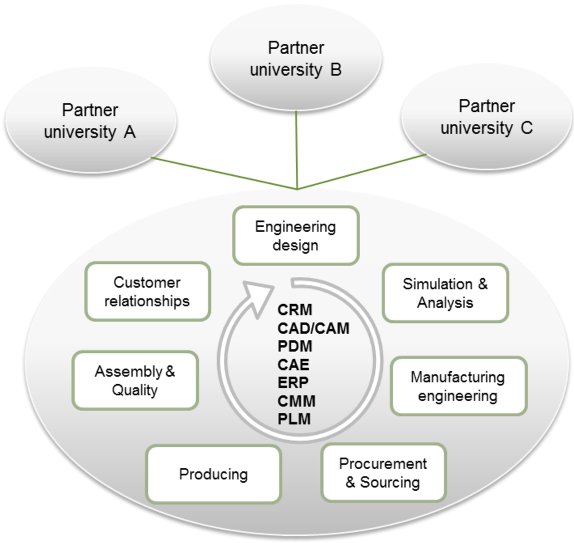

Figure 2. A conceptual model of the FDO learning environment based on the digital product process and distributed design.

5. Discussion

Conventionally, engineering design learning has been based on the assumption of collocated, synchronous working. A new learning environment where students can work effectively in distributed design teams across geographical, cultural and professional boundaries is under development in TUAS. This Future Design Office (FDO) approach is based on the digital product process and tight industry co-operation by solving authentic design problems. Students work in small teams by applying their engineering knowledge for solving these typically, open-ended and ill-structured problems.

This paper discussed especially the learning of new engineering design skills when the design environment is geographically and culturally dispersed and interaction between design teams is ICT mediated. The key engineering skills and competencies that are essential for a distributed product development process are identified. Digitality is a key to the distributed design, because it enables ICT mediated communication both between designers and machines. Geographically distributed design teams can be in interaction by digital means as well as CAD tools and manufacturing machines can communicate with each other. It is characteristic that principally all the design tasks can occur in a collocated or distributed design process, and can be performed in synchronous or asynchronous working modes. Our vision is that when a student achieves experience of all design process stages in a cross-disciplinary team, in a distributed design environment, his/her competence base is added to, deep learning and professional development will occur. We see that this type of learning also develops students' organisational abilities, leadership skills, business understanding, interaction and communication skills, and their ability to work independently.

We have already accepted that this is a big challenge for the degree programme to organise studies for learning distributed design skills, because of the required complex technical and social learning environment and cross-cultural interaction with partner institutions. Wodehouse et al. [4] also concluded that coordinating global design activities were much more complicated and time consuming than they first expected. However, as they did, we also believe that when our staff became more experienced and familiar with the new learning approach and environment there. FDO will operate in a streamlined manner and our students can learn simultaneously, engineering fundamentals, state-of the art design engineering tools, distributed organisational abilities and social skills that will be of great value to modern industry that needs graduates for working in a global context.

This study illustrated the first steps of the planning only. In order to develop the FDO learning environment further, more studies are needed, such as understanding better how students are acquiring, sharing and using engineering design information during their projects. This is important because distributed design teams have limited possibilities of direct face-to-face communication and digitally mediated information flow is a crucial success factor from the cross-disciplinary idea generation, problem solving and project management viewpoints.

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Presenter: The paper is presented by Ari Putkonen.

Towards Critical Success Factors for Enhancing User Trust in Cloud Computing Applications

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Abstract

The use of the cloud is without a doubt the latest appealing technological trend to emerge in the IT industry. However, despite the surge in activity and interest, there are significant and persistent concerns about cloud computing, particularly with regard to trusting the cloud platform in terms of confidentiality, integrity and availability of user data stored through these applications. These factors are significant in determining trust in cloud computing and thus provide the framework for this paper. The significant role that trust plays in adoption and continued use of cloud computing was considered in relation to the Proposed Model of Trust [1] and the Confidentiality-Integrity-Availability (CIA) Triad [2].
Although a number of trust models and cloud computing adoption strategies have been produced, their main focus has been on cost reduction and the various benefits that organisations and users will realise by migrating to the cloud. Most available work on cloud does not provide clear trust enhancing strategies for cloud computing service providers that will ensure user trust in the adoption and successful continued use of cloud computing applications.
This paper reports on findings of a questionnaire administered to users (and potential users) of cloud computing applications. The questionnaire primarily investigates key concerns which result in self-moderation of cloud computing use and factors which would improve trust in cloud computing. Additionally, results relating to user awareness of potential confidentiality, integrity and availability risks are included. Based on the results of this questionnaire, Critical Success Factors (CSFs) to enhance user trust in cloud computing applications are proposed. These CSFs are an enhancement of a previous model suggested by the authors.

Keywords: *Adoption; Availability; Cloud Computing; Confidentiality; Continued Use; Integrity; User Trust*

1. Introduction

Recent advances in the use of technology have pushed technological innovation to new frontiers and cloud computing has emerged as one of these recent web-based innovations. The growing acceptance of innovative technologies in the business world has seen the popularity of cloud computing increase substantially. Cloud computing enables increased productivity and transforms business processes through means that were considered very expensive before [3]. The emergence and application of cloud computing has helped users gain access to various computing resources, more conveniently and it is fast becoming a dynamic force in the business world [4].

However, the volumes and type of data that can be stored and retrieved from the cloud through the use of the Internet threatens the security and trustworthiness of the cloud [5]. Although the use of cloud computing promises various benefits to end-users, successful adoption of cloud computing requires an understanding of the different dynamics that are involved with cloud computing adoption. The lack of trust in the cloud computing platform is seen to have a negative impact on the successful adoption, implementation and continued use of cloud computing.

The increasing lack of trust in cloud computing that hinders successful adoption is widely recognised and highlights the significance of this research. With the proliferation of cloud computing applications for general computer users, a number of security and trust concerns have arisen [5]. For this reason, cloud computing users require a means of assessing whether or not the platform is trustworthy before adopting and using it. This study sets out to explore the most important trust issues, including confidentiality, integrity and availability, around cloud computing adoption for end-users.

A survey based on the constructs of the Proposed Trust Model [1] and the Confidentiality Integrity Availability triad [2] was administered to a convenient sample at an educational institution. The respondents identified perceived barriers to the use of cloud computing applications, specifically with regards to trust, confidentiality, integrity and availability. The results from the survey were analysed making use of descriptive statistical analysis. The results indicate that accountability, security, access, accountability and transparency are key factors to assure end-users of a cloud computing platforms trustworthiness.

Following this introduction, the theoretical background for this paper is provided which highlights the relevance of cloud computing applications, the underlying trust theory for this paper, and the Confidentiality Integrity Availability triad. The methodology, which includes the construction of the survey instrument, is described next. This is followed by an analysis of the survey results in order to identify the Critical Success Factors for enhancing end-user trust in cloud computing. The conclusion, which highlights the contribution made by this paper, is the last section of this paper.

2. Theoretical Background

Despite the vast business and technical advantages of using cloud computing, many potential cloud users are still reluctant to trust and migrate to the cloud [6]. This is largely due to the fact that the convenience and efficiency of cloud computing comes with a range of potential privacy and security related issues that pose a threat to the user’s data. The presence of trust improves and ensures the successful adoption and continued use of the cloud, while the lack of it results in inefficient and ineffective performance and use of the services offered by the cloud [7]. Therefore, a lack of trust hampers the successful adoption of cloud computing and its continued use.

In order to determine the appropriate factors to focus on for this study, a basic content analysis of key articles in the area of cloud computing was discussed. This content analysis (Table 1) forms the basis for the development of the survey described later in this paper.

Table 1. Content Analysis of Cloud Computing Concerns

	Trust	Confidentiality	Integrity	Availability	Security	Adoption	Compliance	Privacy	Risk	Accountability
Shimba (2010)	X	X			X	X				
Callewaert & Luysterborg (2011)	X	X			X			X		
Ko, Jagadpramana, Mowbray, Pearson, Kirchberg, Liang & Lee (2011)			X							X
Krautheim (2010)	X	X								
Microsoft (2009)		X		X	X		X			
Cofta (2007)										
Ragent & Leach (2010)	X			X						
CSA (2010)			X						X	
Farrell (2010)			X	X			X		X	

Ernst & Young (2011)			X	X					X	
Jerico Forum (2009)	X									
Robinson, Lorenzo, Cave, & Starkey (2010)	X	X			X			X		
Chow, Golle, Jakobsson, Shi, Staddon, Masuoka, & Molina (2009)		X			X			X		
LuitBitz (2010)						X				
Schiffman, Moyer & Vijayakumar (2010)	X									
Callewaert, Robinson, & Blatman (2009)										
Lovell (2010)										
Pearson (2009)	X	X						X		
Nyoni & Piderit (2012)	X	X	X	X		X	X	X		X
Lee & Wan (2010)	X					X				
Santos, Gummadi & Rodrigues (2009)	X	X	X							
McKnight, Choudhury & Kacmar's (2002)	X					X				
Kumar, Sehgal, Chauhan, Gupta, & Diwakar, (2011)		X	X	X			X	X		X
Khajeh-Hosseini, Sommerville, & Sriram (2010)						X	X			
ISACA (2009)				X		X				
Zhang, Liu, Li, Haiqiang, & Wu (2011)				X		X				

Trust emerges as the dominant concept in this content analysis of research into cloud computing concerns, with confidentiality, integrity and availability also registering high counts. This suggests the importance of these issues, and thus the paper focuses on these four concepts in the sections that follow.

2.1. The Proposed Trust Model

The Proposed Trust Model [1] has been a predominant model for trust research. This model is based on literature research and developed within the management domain on issues relating to trust. The proposed model distinguishes between trustor and trustee characteristics that foster a trusting relationship between the two parties. Thus, this model is appropriate for the context of user and vendor relationships in cloud computing. The trustor characteristics provide a frame of reference for evaluating a cloud computing vendor, and the trustee characteristics describe the end-user.

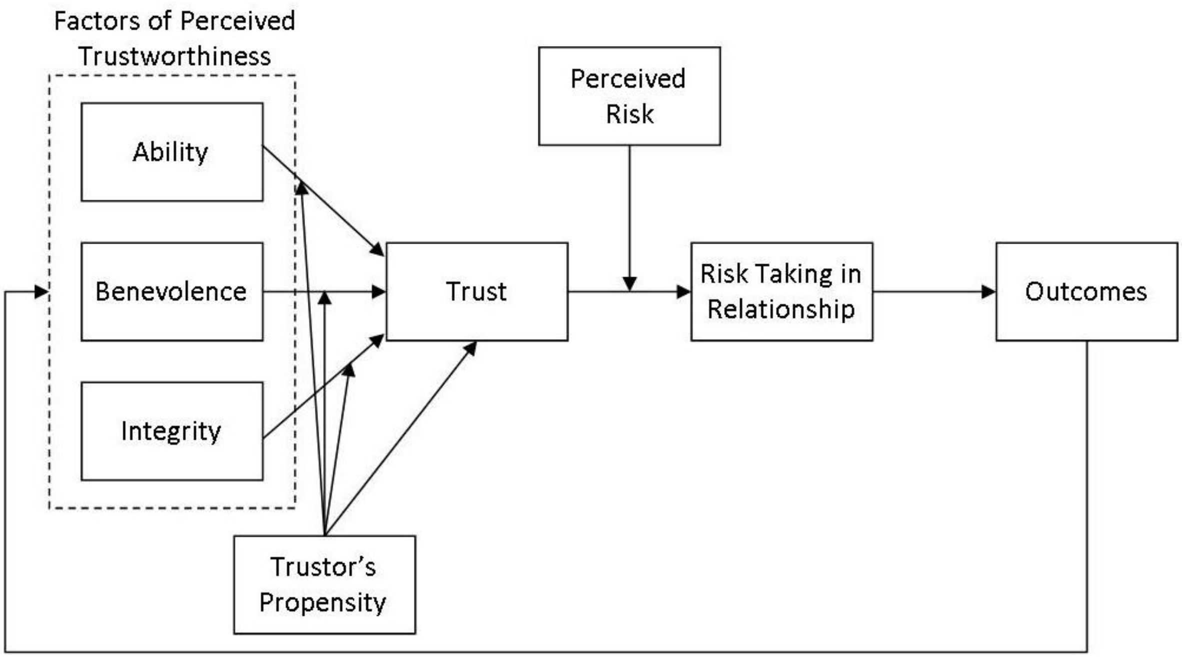

Figure 1 Proposed Model of Trust (Mayer, Davis, & Schoorman, 1995)

In this model (Figure 1) three determinants of a trustee's trustworthiness are proposed, which are ability, integrity and benevolence [1].

1. *Ability*: This is defined as the skills, competencies and characteristics that ensure the trustee has influence in the relationship [1]. It can be further defined as collection of abilities, capabilities and characteristics that enable the trustee to have influence within a specific sphere in this case in the cloud.
2. *Benevolence*: This is defined as the extent to which the trustee is believed to want to act in the trustor's best interests [1]. It relates more to the ethics and moral judgement of the cloud computing service providers that they will act in the trustor's best interests and not to take economic advantage of the cloud computing users.
3. *Integrity*: This is defined as a perception that the trustee prescribes to the principles that the trustor finds acceptable [1]. In the cloud computing scenario, integrity would be based on the cloud vendor's attitude towards honouring his commitments to all the cloud users. It refers to a user's perception that the trustee adheres to a set of principles that the customer finds acceptable.

These key determinants of trust need to be considered when evaluating the cloud computing vendor's trustworthiness. Thus, ability, benevolence and integrity were investigated through the survey in order to identify the related critical success factors for cloud computing users. Further to the trust considerations, the confidentiality, integrity and availability concerns recognised in the content analysis are described in the next section.

2.2. The Confidentiality Integrity Availability (CIA) Triad

Data stored electronically in computers is a valuable asset and should be protected against unauthorized disclosure, tampering or destruction and obstruction to availability [8]. The Confidentiality, Integrity, Availability (CIA) Triad is an industry-accepted model for ensuring security in systems in order to further enhance trust in the systems. It specifically focuses on the storage and management of data. This theory was investigated through the survey administered to cloud computing users.

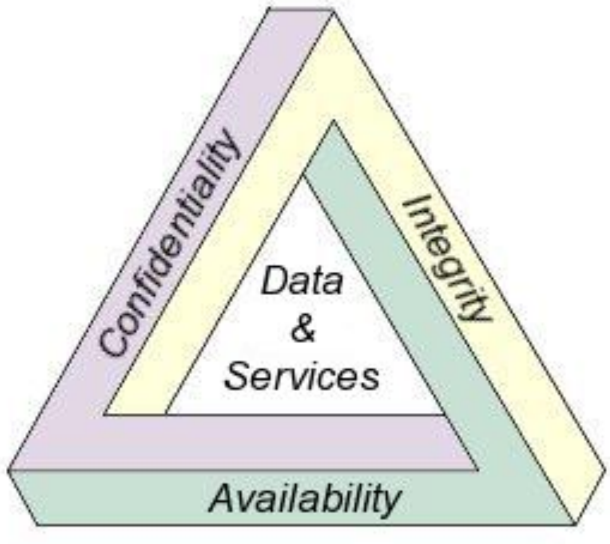

Figure 2: The CIA Triad [2]

As identified by the content analysis earlier, confidentiality, integrity and availability are key concerns with cloud computing. Thus, they require further investigation in order to enhance user trust in the cloud computing applications.

1. *Confidentiality*: This talks to the issue that user's information and data should only be disclosed to authorised parties [9]. Confidentiality is the prevention of unauthorized disclosure of information. The vendors will have to make sure that user's data confidentiality is ensured by

network security protocols, network authentication service and data encryption services [9]. Confidentiality is an important part of the trust relationship between the cloud vendor and users. The vendor's failure to ensure confidentiality will result in a loss of trust, damage to vendor's reputation and legal implications [8].

2. *Integrity*: Information, either in transmission or in storage, must not be changed or destroyed accidentally or worse, intentionally, by unauthorized parties. It must remain in a consistent state. Integrity therefore is the guarantee by vendors that data received and data in transit will not be altered. This is ensured by firewall services, communication security and interference detection [9].
3. *Availability* is the guarantee that information will be available to the consumer in a timely and uninterrupted manner when it is needed regardless of location of the data [9]. This means that the cloud infrastructure, the security controls, and the networks connecting the clients and the cloud infrastructure should always be functioning correctly. Availability is ensured by: fault tolerance, authentication and network security.

Based on the Trust and CIA constructs above, a survey was constructed to investigate user's perceptions of trustworthiness of cloud computing applications. The section that follows describes the methodology followed in this study.

3. Methodology

This study focused on identifying the trust, confidentiality, integrity and availability concerns relevant for user adoption of cloud computing application. Due to the nature of the surveys used in this study, a positivistic influence emerges, namely "reality as a contextual field of information" [10].

The research instrument was a formal, web based survey investigating user's perceptions of the trust, confidentiality, integrity and availability issues when adopting cloud computing. The quantitative data from the web-based survey was analysed and the responses summarised to be meaningful and to identify trends through the use of charts and graphs. These findings provide the basis for the recommendations, namely Critical Success Factors (CSFs) to enhance user trust in cloud computing applications are proposed.

The survey administered to participants was based on the constructs of the Proposed Trust Model [1]and the CIA Triad [2] as follows:

1. *Ability*: Respondents were asked to comment on the degree to which the cloud computing service provider's security practices affected use of the services. Additionally, they were asked about the effect which transparency and data recovery practices impact their assessment of the platform.
2. *Benevolence*: Respondents were asked to comment on the degree to which the cloud computing service provider's reputation affected use of the services. Additionally, they were asked about the effect which consistency and accountability practices impact their assessment of the platform.
3. *Integrity*: Respondents were asked to comment on the degree to which the cloud computing service provider's compliance practices affected use of the services.
4. *Confidentiality:* Respondents were asked to comment on the degree to which the cloud computing service provider's privacy practices affected use of the services. Additionally, they were asked about the effect confidentiality practices impact their assessment of the platform.
5. *Availability:* Respondents were asked to comment on the degree to which the cloud computing service provider's control practices affected use of the services. Additionally, they were asked about the effect which availability on demand and ease of access impact their assessment of the platform.

The results for these five constructs are described below.

4. A Survey of Cloud Computing Users

The factors affecting user trust in cloud computing applications were investigated according to the constructs of the Proposed Model of Trust [1] and CIA Triad [2], namely: Ability, Benevolence, Integrity, Confidentiality and Availability. The findings from the survey relating to these constructs are provided in the sections that follows.

4.1. Ability

Three questions in the survey focused on the effect of ability on user trust in cloud computing applications. Respondents were asked to acknowledge whether or not the attributes described would improve trust in a cloud computing platform. The results of these three questions are shown in Table 2.

Table 2: Ability Results

Attribute	% Response
Security Practices	82%
Transparency	54%
Disaster Recovery Practices	66%

The results indicate that the participants found that security practices were the most relevant mechanism to assure users of the ability of a cloud computing service provides.

4.2. Benevolence

Three questions in the survey focused on the effect of benevolence on user trust in cloud computing applications. Respondents were asked to acknowledge whether or not the attributes described were a cause of concern when using a cloud computing platform. The results of these three questions are shown in Table 3.

Table 3: Benevolence Results

Attribute	% Response
Reputation	36%
Consistency	62%
Accountability	66%

The results indicate that the participants found that Consistency and Accountability were the most relevant concerns which need to be addressed to assure users of the platform’s trustworthiness.

4.3. Integrity

Two questions in the survey focused on the effect of integrity on user trust in cloud computing applications. Respondents were asked to acknowledge whether or not the attributes described would improve trust in a cloud computing platform. The results of these three questions are shown in Table 4.

Table 4: Integrity Results

Attribute	% Response
Legal Compliance	24%
Industry Regulatory Compliance	54%

The results indicate that the participants found that compliance to industry standards were the most relevant mechanism to assure users of the ability of a cloud computing service provides.

4.4. Confidentiality

Two questions in the survey focused on the effect of confidentiality on user trust in cloud computing applications. Respondents were asked to acknowledge whether or not the attributes described were a cause of concern when using a cloud computing platform. The results of these three questions are shown in Table 5.

Table 5: Confidentiality Results

Attribute	% Response
Confidentiality of Data	76%
Privacy of Data	66%

The results indicate that the participants found that Confidentiality of the data is the most relevant concern which needs to be addressed to assure users of the platform's trustworthiness.

4.5. Availability

Three questions in the survey focused on the effect of availability on user trust in cloud computing applications. The first question, "Was the loss of control over your data a concern when using cloud computing applications?", focused on the control concerns of using cloud computing. The second question, "How important is it that your data is available on demand?", focused on the availability concerns of using cloud computing. The third question, "How important is it that your data is easily accessible?", focused on the accessibility concerns of using cloud computing. The results of these three questions are shown in Table 6.

Table 6: Availability Results

Question	Median	Mean	Agree	Disagree
Was the loss of control over your data a concern when using cloud computing applications?	1 (Strongly Agree)	1.88 (Strongly Agree)	74%	26%
How important is it that your data is available on demand?	2 (Agree)	1.86 (Strongly Agree)	80%	20%
How important is it that your data is easily accessible?	1 (Strongly Agree)	2.08 (Agree)	74%	26%

The results indicate that control of the data, availability and ease of access are important factors in determining trust in a cloud computing platform.

From the results described in the preceding sections, Critical Success Factors for enhancing user trust in cloud computing are proposed in the section that follows.

5. Critical Success Factors for Enhancing User Trust in Cloud Computing

The table below describes the Critical Success Factors (CSF) proposed based on the empirical findings described above. Each CSF is stated and then linked to the theoretical and empirical findings which led to its inclusion.

Table 7: Critical Success Factors for Enhancing User Trust in Cloud Computing

Critical Success Factor	Theoretical Findings	Empirical Findings
Security mechanisms must be adequate and operational.	Proposed Model of Trust – Ability construct	82% of respondents believed this to be relevant for enhancing trust.
Service Level Agreements between users and service providers must ensure service	Proposed Model of Trust – Benevolence construct	66% of respondents believed this to be a concern for users of cloud computing services.

providers are accountable for inappropriate use of data.		
Cloud Computing service providers must comply with industry regulations.	Proposed Model of Trust and CIA Triad – Integrity construct	54% of respondents believed this to be a concern for users of cloud computing services.
Cloud Computing Service Providers must ensure confidentiality of user data.	CIA triad – Confidentiality construct	76% of respondents believed this to be a concern for users of cloud computing services.
Users must remain in control of their data.	CIA triad – Availability construct	74% of respondents believed this to be relevant for enhancing trust.
Users' data must be available for use at all times.	CIA triad – Availability construct	80% of respondents believed this to be relevant for enhancing trust.
Users should be able to easily access their data.	CIA triad – Availability construct	74% of respondents believed this to be relevant for enhancing trust.

6. Conclusion

This paper tested the constructs of the Proposed Trust model and the CIA Triad in order to determine the critical success factors (CSFs) for enhancing user trust in cloud computing. From the findings of the survey distributed to participants in an educational institution, seven CSFs were identified relating to security, accountability, compliance, confidentiality, control, availability and access.

These findings confirm the relevance of the constructs of the Proposed Trust model and the CIA Triad in this context. The CSFs proposed are to be considered by a user before adopting and using a new cloud computing platform. This is the key contribution of this paper.

Further research conducted into enhancing user trust in cloud computing should propose CSFs from a service provider point of view. The CSFs suggested in this paper can also be expanded into a framework to assist new cloud computing users to determine the appropriateness of a cloud computing service.

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Identifying Barriers to Citizen Participation in Public Safety Crowdsourcing in East London

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Abstract

The value of crowdsourcing in a public safety context is realised when a large group of people within a geographical area report on matters which they have experienced or witnessed. This provides the relevant authorities with useful information in order to respond to the incident and assists in planning future interventions – thus allowing local governments to act proactively rather than reactively.

The Public Safety Crowdsourcing Project aims to use the citizens of East London as the information source to report on public safety matters. In order for the Public Safety Crowdsourcing Project to be successful, it relies on citizens reporting the public safety matters they observe or experience. As participation in crowdsourcing is voluntary, the adoption barriers and challenges identified differ to those acknowledged in traditional system adoption scenarios. The focus here is on factors that affect participation, and thus, this paper sets out to identify the key barriers to citizen participation in public safety crowdsourcing.

The barriers to citizen participation are identified through a survey administered to participants who reported public safety matters. The survey is based on the constructs of the Unified Theory of Acceptance and Use of Technology (UTAUT), namely: Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions. The UTAUT model was used to test the current crowdsourcing model. From this study, it emerges that citizen participation can be improved through incentives which encourage participation and reliance on voluntary participation has been a key factor in the poor uptake of public safety crowdsourcing.

Keywords: *Adoption Barriers, Crowdsourcing, Participation, Public Safety, UTAUT.*

1. Introduction

Crowdsourcing is recognised as an innovative means of creating value from willing participants [1]. This involves the collection of information from a large group of people for a particular purpose, rather than relying on the individual contributions traditionally expected. For the Public Safety Crowdsourcing Project, the type of information required concerns public safety matters. Recently, the value of crowdsourcing for mapping a range of public safety matters, such as crime, traffic, infrastructure or natural disasters, has been recognised. By accessing the collective knowledge of the crowd about these public safety matters, the relevant authorities are able to obtain more accurate information on which to base planning for future interventions than would otherwise be possible [1].

The Public Safety Crowdsourcing Project provides a platform for the citizens of East London to report public safety matters they observe, thus acting as the information source. The participants reported public safety matters by making use of an interactive voice recording (IVR) system. From these reports, information is extracted in order to identify trends in the collected data. These trends can be used by the relevant authorities in order to ensure public safety matters are dealt with proactively rather than reactively by planning necessary interventions. However, in order for this approach to be effective sufficient data needs to be generated by the citizens [2]. For this reason, ensuring citizen participation is a necessary concern.

While the value of this project for East London citizens should be apparent, participation has been relatively low. Thus, the barriers and challenges for citizen participation in the Public Safety Crowdsourcing Project need to be investigated. As participation in this project is voluntary, these barriers and challenges differ to those of traditional systems. While several models and frameworks exist for overcoming perceived barriers, these do not address the unique situation which applies in a voluntary, or participatory, crowdsourcing model. Thus this paper sets out to identify barriers to participation and provide recommendations to overcome these.

A survey based on the relevant constructs of the Unified Theory of Acceptance and Use of Technology (UTAUT) was administered to those citizens who had participated in the Public Safety Crowdsourcing Project by reporting a public safety matter they had observed. The participants identified perceived barriers to further participation in the project. The results from the survey were analysed making use of descriptive statistical analysis. The results indicate that facilitating conditions relating to cost are an important barrier to citizen participation in the Public Safety Crowdsourcing Project. Providing incentives for participation is recommended as a means of overcoming this barrier to citizen participation.

Following this introduction, the theoretical background for this paper is provided which highlights the value of crowdsourcing for public safety matters and the underlying theory for this paper (UTAUT). The methodology, including a background to the project and the construction of the survey instrument, are described next. This is followed by an analysis of the survey results in order to identify the barriers to citizen participation. The recommendations and conclusion, which highlight the contribution made by this paper, are the last section of this paper.

2. Theoretical Background

As the worldwide population continues to move toward urban areas where service delivery is expected to be better, the existing infrastructure of these cities is placed under severe strain [2]. Thus, more innovative means of providing service delivery is required. Crowdsourcing is proposed as an appropriate means of overcoming the challenges presented by continued urbanisation. An overview of crowdsourcing and the Unified Theory of Acceptance and Use of Technology is provided in this section.

2.1. Participatory Crowdsourcing

The crowd can be used to gather information through either sensing (where devices such as mobile phones provide information) or sourcing (where the crowd provides information) [3]. The most successful crowdsensing applications include: Urban Sensing, MetroSense and Nokia Sensor Planet [3]. There are also several well-known examples of crowdsourcing, namely: Wikipedia, iReport, reCAPTCHA and Amazon Mechanical Turk [3]. There are generally three models of participatory crowdsourcing [4]:

- *Required*: used in situations where one party has influence over another, for example employees.
- *Paid*: where monetary compensation is provided for contributions, for example Amazon Mechanical Turk.
- *Voluntary*: where no compensation is provided for contributions, for example Wikipedia.

The value of using the crowd to contribute to Wikipedia is that the content is continuously updated and improved [5]. This however, relies on voluntary participation without any compensation. On the other hand, Amazon Mechanical Turk acts as an interface between “requestors” and “workers”, who are paid for completing tasks [5]. The difference between these two models highlights an important trade-off between information quality and compensation [6]. Importantly, it is noted that quality cannot be guaranteed where there is no control over the crowd; therefore a form of compensation is needed.

In the public safety context, the salient benefit of crowdsourcing is the use of ordinary citizens to provide data on events they observe. However, this relies on the citizens motivation to participate [7]. The gathered data can be used to the benefit of the citizens in order anticipate future public safety matters and identify trends which indicate repetitive concerns [2]. This is consistent with the trend toward proactive approaches to handling public safety matters.

The cost of establishing a crowdsourcing initiative for public safety matters is low for the local government authorities who would use the information as it relies largely on existing telephone and software infrastructure can be utilised [2]. Also, the use of mobile phones allows citizens to report public safety matters as they occur, and allow for a larger geographical area to be covered.

2.2. The Unified Theory of Acceptance and Use of Technology (UTAUT)

This paper is based on the Unified Theory of Acceptance and Use of Technology (UTAUT) as proposed by [2]. UTAUT was proposed due to the existence of numerous models which reported on different acceptance determinants [8]. As this model drew on eight prominent acceptance models, proposed a unified model incorporating common constructs from the eight models and empirically tested the proposed model to confirm the applicability of it, it is an appropriate theory on which to base this paper.

As reported, the key constructs on which all user acceptance models are based are: individual reactions to using IT, intentions to use IT and actual use of IT [8]. This is depicted in Figure 1 below.

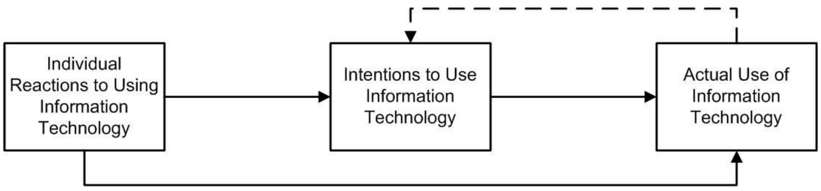

Figure 1. Basic Concepts Underlying User Acceptance Models [8]

As shown in Figure 1, intention to use IT predicts a user's behaviour (also referred to as Actual Use). The relationship between these two constructs is well-established in existing literature [8] and has repeatedly been confirmed in empirical studies [9], [10]. What is necessary to establish is the factors which inform the user's reaction to using a technology, which determines their future intention to use IT and therefore their actual use. This is the key contribution of the UTAUT model depicted in Figure 2.

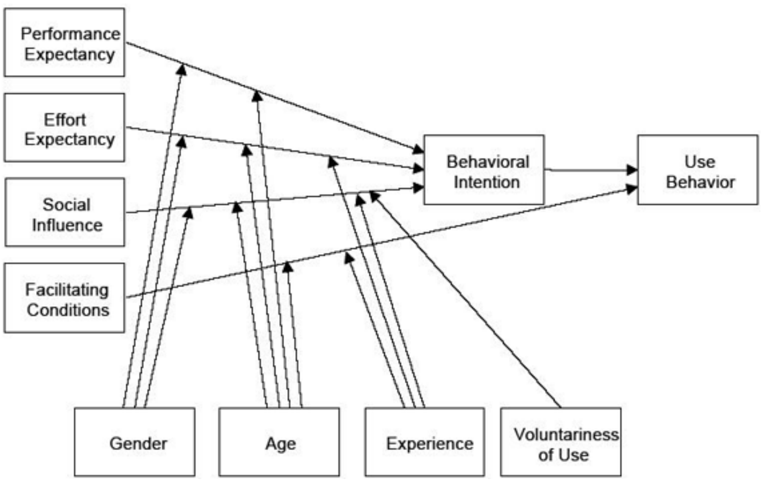

Figure 2. Unified Theory of Acceptance and Use of Technology [8]

UTAUT establishes four determinants of intention, namely:

1. *Performance Expectancy*: This is the degree to which the user (or citizen) believes the system will assist them in attaining their goal, and is the strongest predictor of intent to use.
2. *Effort Expectancy*: This is the degree to which the user (or citizen) believes the system is easy to use.
3. *Social Influence*: This is the degree to which the user (or citizen) believes their use of the system will be viewed favourably by their peers.
4. *Facilitating Conditions*: This is the degree to which the user (or citizen) believes the necessary organisational and technical infrastructure exists to support their use of the system.

These four determinants are considered to be moderated by gender, age, voluntariness of use and experience [8]. This UTAUT model provides a unified view of the factors that affect a user's usage of a technology implementation [8]. For this reason it is used to assess the factors hindering citizen participation in public safety crowdsourcing. The methodology followed in the investigation is discussed in the section that follows.

3. Methodology

This study focused on identifying barriers and challenges to citizen participation in the Public Safety Crowdsourcing Project. Due to the nature of the surveys used in this study, a positivistic influence, namely "reality as a contextual field of information" [11].

The research instrument was a formal, web based survey investigating citizen's perceptions of the barriers to participation in the Public Safety Crowdsourcing Project. Of the 181 registered participants, 52 completed the survey. The quantitative data from the web-based survey was analysed and the responses summarised to be meaningful and to identify trends through the use of charts and graphs. These findings provide the basis for the recommendations for overcoming barriers to citizen participation.

3.1. The Public Safety Crowdsourcing Project

The Public Safety Crowdsourcing Project was carried out in East London, which falls within the Buffalo City Municipality. The current population is estimated at 440 000 [12]. In terms of public safety matters, the Directorate of Health and Public Safety provides for traffic and law enforcement, fire and rescue services, and disaster management [2].

The Public Safety Crowdsourcing Project was initiated in order to propose and test a participatory crowdsourcing model for a developing country. An Interactive Voice Recognition (IVR) system was developed in conjunction with IBM to provide a platform for citizens to report public safety matters. The IVR directed citizens through the process of reporting a matter via voice prompts [2].

Participants from the East London area were recruited through newspaper advertisements, distributed flyers and social media. In order to record public safety reports, participants were required to first register on the Project's website and accept the terms and conditions for participation. After registering, participants were expected to place calls to the IVR to report public safety matters. Thereafter, they completed the online survey to comment on their perceptions of the barriers to participation. In order to encourage participation in the Project, three iPads were awarded to randomly selected participants who had made a call and completed the survey. This incentive is in line with the second participatory crowdsourcing model discussed in Section 2.1. Figure 3 provides a graphical representation of this process.

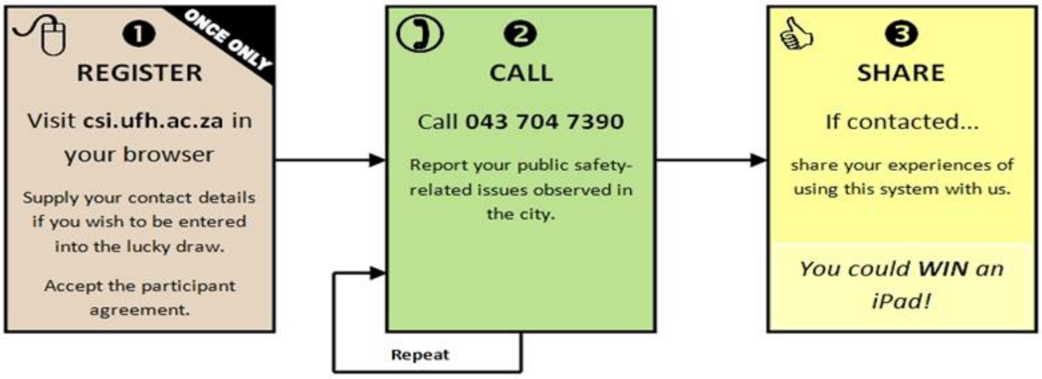

Figure 3. Steps of the Public Safety Project

During the course of the project, 65 000 flyers were distributed in the East London area. Additionally, advertisements were placed in the community newspaper which has a readership of 30 000 in the East London area. These were aimed at raising awareness of the Project and encouraging participation. These measures were over and above the iPad incentives mentioned previously.

3.2. The Survey

The survey administered to participants was based on the constructs of the UTAUT model as follows:

1. *Performance Expectancy*: Respondents were asked to comment on the degree to which the system assisted them in reporting public safety matters.
2. *Effort Expectancy*: Respondents were asked to rate the degree to which instructions were clear and the degree to which they found reporting a public safety matter to be an intimidating experience.
3. *Social Influence*: Respondents were asked to rate the degree to which they feared using the system and the degree to which their peers would view their use of the system as favourable.
4. *Facilitating Conditions:* Respondents were asked to rate the degree to which cost of participating and personal resources determined their use.

The moderating factors identified in the UTAUT model were not considered as part of this study, and could form the scope for future research. Of the 181 participants in the Public Safety Crowdsourcing Project, 52 completed the survey. The Cronbach Alpha for the four constructs tested in the survey is 0.71 which is considered acceptable for studies leaning toward social sciences [13].

4. Identifying the Barriers to Citizen Participation in Public Safety Crowdsourcing

As discussed previously, individual reaction to using IT persuades their intention to use IT, which in turn predicts a user's behaviour (also referred to as Actual Use). These concepts are depicted in Figure 3 and adapted for the context of the Public Safety Crowdsourcing Project.

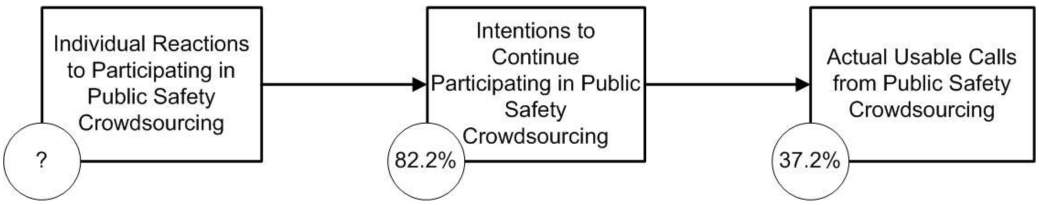

Figure 3. Basic Concepts Underlying User Acceptance Models [Adapted from: 2]

In the context of the Public Safety Crowdsourcing Project, the Intention to Continue Participating to report public safety matters has been determined to be 82.2% by previous studies [2]. While several hundred calls were placed to the platform, only 37.2% were usable for analytical purposes. Reasons for calls being classified as unusable have been identified by previous studies, including: insufficient information, illegible recording, or incomplete calls [14]. Thus, the reaction to actual use of the platform needs to be determined, in order to identify barriers which need to be overcome in order to improve the participation in public safety crowdsourcing.

These barriers were investigated according to the four constructs of the UTAUT model, namely: Performance Expectancy, Effort Expectancy, Social Influence and Facilitating Conditions. The findings from the survey relating to these constructs are provided in the sections that follows.

4.1. Performance Expectancy

Performance expectancy of the Public Safety Crowdsourcing Project was tested in a related paper [2]. In the paper, the authors report on the results from two questions which relate to the ability of the crowdsourcing system, namely: "Were you satisfied that you could report your public safety matter efficiently", which focused on the ability of the system, and "I trust the system to reflect my public safety matter correctly", which focused on the trust of the user in the system [2]. The results reported for the two questions can be found in Table 1.

Table 1: Ability of the participatory crowdsourcing system [2]

Question	Median	Mean	Agree	Disagree
Were you satisfied that you could report your public safety matter efficiently?	2 (Agree)	1.92 (Agree)	83.62%	5.85%
I trust the system to reflect my public safety matter correctly.	2 (Agree)	1.82 (Agree)	85.27%	1.16%

The results indicate that the participants believed the performance of the crowdsourcing systems was efficient and that they believe that they are able to correctly report public safety matters.

4.2. Effort Expectancy

Two questions in the survey focused on the effort expectancy relating to reporting public safety matters. The first question, "Were the instructions for participating in the CSI Public Safety project and reporting public safety issues adequate?", focused on the ease of use of the IVR for reporting a public safety matter. The second question, "Did your experience while reporting public safety issues cause any confusion?", focused on the extent to which the process of using the system was clear to the citizens. The results of these two questions are shown in Table 2.

Table 2: Effort Expectancy of participating in the Public Safety Crowdsourcing Model

Question	Median	Mean	Agree	Disagree
Were the instructions for participating in the CSI Public Safety project and reporting public safety issues adequate?	2 (Agree)	2.31 (Agree)	70.73%	14.63%
Did your experience while reporting public safety issues cause any confusion?	4 (Disagree)	3.68 (Neutral)	14.63%	70.73%

The results indicate that the participants found the instructions provided for reporting public safety matters were adequate, and that the use of the system did not result in any confusion.

4.3. Social Influence

Two questions in the survey focused on the social influence relating to reporting public safety matters. The first question, "Did you hesitate to participate for fear of making a mistake?", focused on the citizen's perception of the support and encouragement afforded them while reporting a public safety matter. The second question, "Did you find reporting a public safety issue to be an intimidating experience?", focused on the citizen's anxiety related to IVR for reporting a public safety matter. The results of these two questions are shown in Table 3.

Table 3: Social Influence of participating in the Public Safety Crowdsourcing Model

Question	Median	Mean	Agree	Disagree
Did you hesitate to participate for fear of making a mistake?	4 (Disagree)	3.65 (Neutral)	12.20%	63.41%
Did you find reporting a public safety issue to be an intimidating experience?	4 (Disagree)	3.43 (Neutral)	21.95%	53.66%

The results indicate that the participants found that they were sufficiently supported and thus did not fear making mistakes while reporting public safety matters. Half of the respondents did not find reporting public safety matters to be intimidating.

4.4. Facilitating Conditions

Two questions in the survey focused on the facilitating conditions relating to reporting public safety matters. The first question, “Was the cost of reporting a significant barrier to reporting a public safety issue?”, focused on the cost of participation using an IVR for reporting a public safety matter. The second question, “Did you have the necessary resources (e.g. phone, airtime) to report public safety issues?”, focused on the extent to which the participants have access to resources required to participate. The results of these two questions are shown in Table 4.

Table 4: Facilitating Conditions of participating in the Public Safety Crowdsourcing Model

Question	Median	Mean	Agree	Disagree
Was the cost of reporting a significant barrier to reporting a public safety issue?	2 (Agree)	2.43 (Agree)	56.10%	28.14%
Did you have the necessary resources (e.g. phone, airtime) to report public safety issues?	2 (Agree)	2.36 (Agree)	61.00%	28.14%

The results indicate that half of the participants found the cost to be a barrier to participation. Most of the participants had access to the necessary resources to participate.

5. Recommendations: Overcoming Barriers to Citizen Participation

From the findings, telephone cost appears to be the key barrier to citizen participation. Additionally, some participants found the experience to be intimidating. Access to resources required to report a public safety matter does not appear to be a significant concern and instructions provided in the IVR were clear enough.

As cost and intimidation were the most significant barriers identified, this could suggest the need to embrace a different platform for reporting public safety matters. While existing public safety-related social networking sites exist and indicate that they could be an efficient means of collecting this information, this would exclude a significant portion of the population from reporting due to access issues.

Providing a toll-free number for the platform would overcome the cost factor for participants. This is an important consideration should this model be implemented in a South African city. The key reason for this concern is the high cost of telephony in South Africa which will continue to provide a barrier to participation.

With regards to the constructs of the UTAUT model, facilitating conditions are the key barrier identified from the findings. In order to overcome this barrier, incentivizing participation is necessary. While iPads were used as incentives in this project, financial incentives may have more impact, and thus a future iteration of this project could involve recruited participants who are awarded airtime for each completed call. This will further test the relevance of incentives in overcoming the barriers related to facilitating conditions. This approach is supported by authors who view financial rewards as being the key motivator for individual participation in crowdsourcing [15].

6. Conclusion

This paper tested the four constructs of the UTAUT model in order to determine the theory's applicability to a participatory crowdsourcing project. From the findings of the survey distributed to participants in the Public Safety Crowdsourcing project, facilitating conditions, specifically cost of participation, emerged as a key barrier. This cost of participation is not restricted to financial cost, but includes time and effort of participation.

These findings confirm the relevance of the facilitating conditions construct of the UTAUT model. The other three constructs, namely: Performance Expectancy, Effort Expectancy and Social Influence, have less of an impact on participation, but are still relevant. As a means of overcoming these participation barriers, incentives for participation are recommended. This is the key contribution of this paper.

Further research conducted into the barriers to citizen participation could investigate the Moderating Factors of the UTAUT model in order to determine means of providing equal access and opportunity to participate to all citizens. Additionally, incentivizing participation for a recruited group of participants should be investigated in order to confirm these findings.

7. Acknowledgements

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Application of Linguistic Fuzzy-Logic Control in Technological Processes and Problem-based Learning

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Abstract

This paper presents the use of modern numerical methods such as Fuzzy Logic Control for control of fast technological processes with sampling period 0.01 [s] or less. The paper presents a real application of the Linguistic Fuzzy-Logic Control, developed at the University of Ostrava for the control of helicopter model in the laboratory at the Department of Informatics and Computers the Faculty of Science. This technology and real models are used as a background for problem-oriented teaching, realised at the department for master students and their collaborative as well as individual final projects. The paper presents two examples of student's project realised using a helicopter model and obtained results which show how modern information technologies can help students in their study and prepare them for solving actual technical problems with help of the presented technologies. The paper shows how the used technology can help people easily describe the control strategy both from technological and helicopter pilot's control strategy point of view. The presented results of every project have been obtained by a student team during one exercise (1.5 hour).

Keywords: *Fuzzy Logic, Control, LFLC, Problem-based Learning.*

1. Introduction

Fuzzy logic has been invented by Prof. Zadeh [1] and used to describe uncertain systems [2] since the 60's of the 20th century. This technique has also been used in control systems. Fuzzy control is now the standard control method which is a constituent of many industrial systems and companies advertise it no more. The used technique is mostly based on application of fuzzy IF-THEN rules; either of the form first used by Mamdani [3], or by Takagi and Sugeno [4]. The success of fuzzy logic control is based on the fact that a description of real systems is quite often imprecise. The imprecision arises from several factors—too large complexity of the controlled system, insufficient precise information, presence of human factor, necessity to spare time or money, etc. Frequently, combination of more such factors is present.

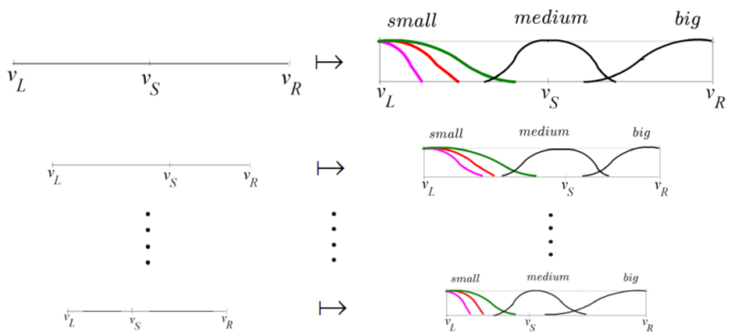

Figure 1. A general scheme of intension of evaluative expressions (extremely small, very small, small, medium, big) as a function assigning to each context $w \in W$ a specific fuzzy set [7].

A special system for fuzzy logic control has been developed at the University of Ostrava by Prof. Novák and his team [5] – [7] based on linguistic description. The Linguistic Fuzzy Logic Controller (LFLC) is the result of application of the formal theory of the fuzzy logic in broader sense (FLb). The fundamental concepts of FLb are evaluative linguistic expressions and linguistic description. Evaluative (linguistic) expressions are natural language expressions such as small, medium, big, about twenty-five, roughly one hundred, very short, more or less deep, not very tall, roughly warm or medium hot, roughly strong, roughly medium important, and many others. They form a small, but very important, constituent of natural language since we use them in common sense speech to be able to evaluate phenomena around. Evaluative expressions have an important role in our life because they help us determine our decisions, help us in learning and understanding, and in many other activities.

Simple evaluative linguistic expressions (possibly with signs) have a general form <linguistic modifier><TE-adjective> (where <TE-adjective> is one of the adjectives (also called gradable) "small – sm, medium – me, big – bi" or "zero – ze". The <linguistic modifier> is an intensifying adverb such as "extremely – ex, significantly – si, very – ve, rather – ra, more or less – ml, roughly – ro, quite roughly – qr, very roughly – vr"), see Figure 1. LFLC is a good tool to define the control strategy, then we also use it for control of technological processes with sampling period 0.01 [s] or less. This paper presents results obtained by students solving problems with control of a helicopter model, representing a fast control system. This model is very helpful for application of problem-based learning, because its description and mathematical model is available, for example [8], see Figure 2.

Next chapters present two real project solved by students during completion of subject "Fuzzy Modeling and Control". The main goal of this subject is to understand basic principles of automatic control and to be able to define control strategies for different requirements and control plants especially with help of LFLC. They also compare obtained results with different Fuzzy control strategies, for example [9] or [10]. Students work in small teams and solve specified projects with help of real plant models. A typical set of projects based on the helicopter model is:

1. Identification of helicopter elevation, obtaining mathematical model (1 exercise).
2. Position control of helicopter elevation (1 exercise).
3. Pilot control strategy model (1 exercise).
4. Control of both helicopter axes (2 exercises).

Figure 2. Helicopter model.

2. Position Control

Typical first problem, solved by students is the position control of the helicopter elevation. They can use LFLC very easily and define the control strategy for reaction to the elevation control error, see Figure 3. A LFLC inference block connects the LFLC controller defined as monotone by next rules:

<table>
<tr><td>"-exbi" | "-exbi"</td><td>"exsm" | "exsm"</td></tr>
<tr><td>"-sibi" | "-sibi"</td><td>"sism" | "sism"</td></tr>
<tr><td>"-vebi" | "-vebi"</td><td>"vesm" | "vesm"</td></tr>
<tr><td>"-mlbi" | "-mlbi"</td><td>"mlsm" | "mlsm"</td></tr>
<tr><td>"-robi" | "-robi"</td><td>"rosm" | "rosm"</td></tr>
<tr><td>"-qrbi" | "-qrbi"</td><td>"qrsm" | "qrsm"</td></tr>
<tr><td>"-vrbi" | "-vrbi"</td><td>"vrsm" | "vrsm"</td></tr>
<tr><td>"-rabi" | "-rabi"</td><td>"rasm" | "rasm"</td></tr>
<tr><td>"-tyme" | "-tyme"</td><td>"tyme" | "tyme"</td></tr>
<tr><td>"-rasm" | "-rasm"</td><td>"rabi" | "rabi"</td></tr>
<tr><td>"-vrsm" | "-vrsm"</td><td>"vrbi" | "vrbi"</td></tr>
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<tr><td>"-rosm" | "-rosm"</td><td>"robi" | "robi"</td></tr>
<tr><td>"-mlsm" | "-mlsm"</td><td>"mlbi" | "mlbi"</td></tr>
<tr><td>"-vesm" | "-vesm"</td><td>"vebi" | "vebi"</td></tr>
<tr><td>"-sism" | "-sism"</td><td>"sibi" | "sibi"</td></tr>
<tr><td>"-exsm" | "-exsm"</td><td>"exbi" | "exbi"</td></tr>
<tr><td>"ze" | "ze"</td><td></td></tr>
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Figure 4 presents the testing software, which presents the reaction of LFLC Controller (static characteristic). Results of the step response are presented in Figure 5.

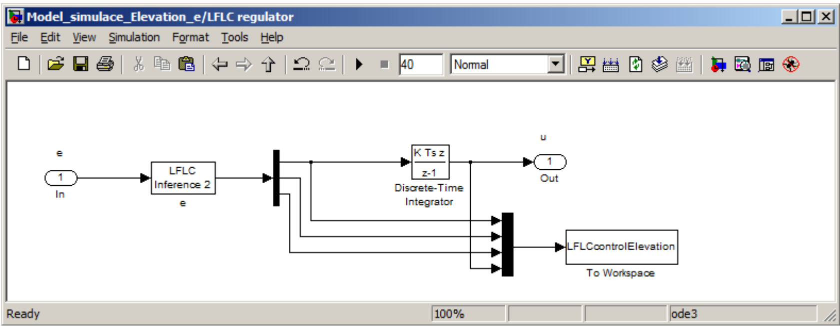

Figure 3. LFLC position controller.

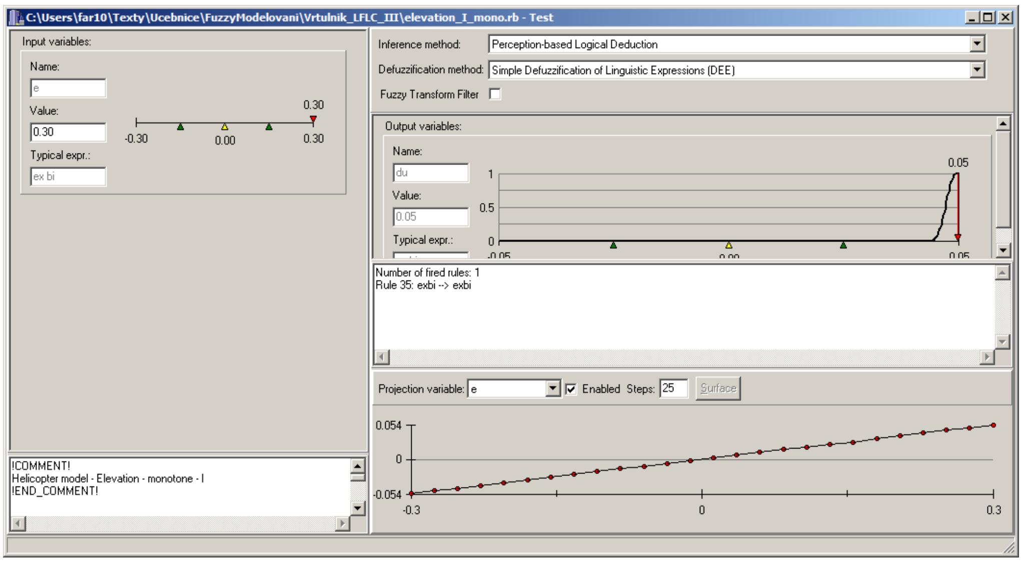

Figure 4. LFLC position controller test.

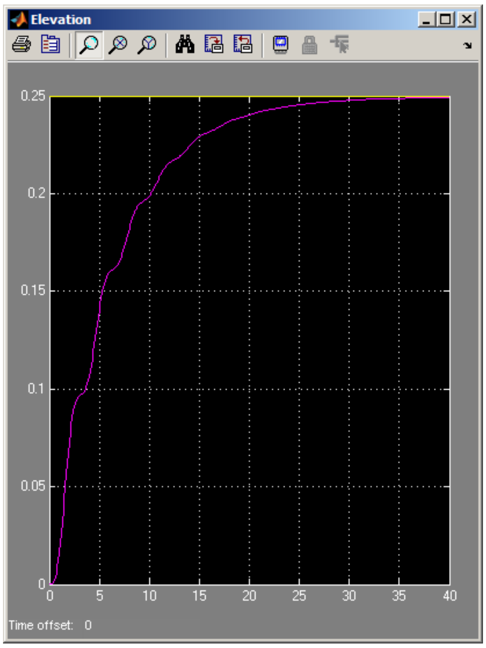

Figure 5. LFLC control result

It is obvious that the result is not appropriate, but we see that even such an easy strategy is helpful. Now students can include reaction to the control error derivatives (first and second), see Figure 6. It is also easy to change the control strategy, for example to a very small reaction to a small error and a very big reaction to a big error to obtain the needed value faster, see Figure 7.

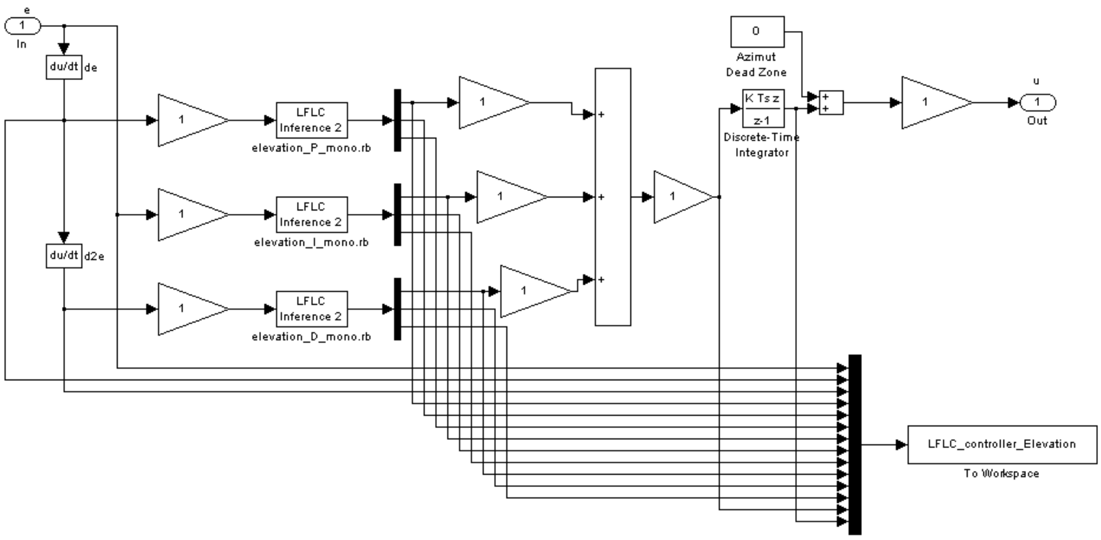

Figure 6. Final LFLC controller

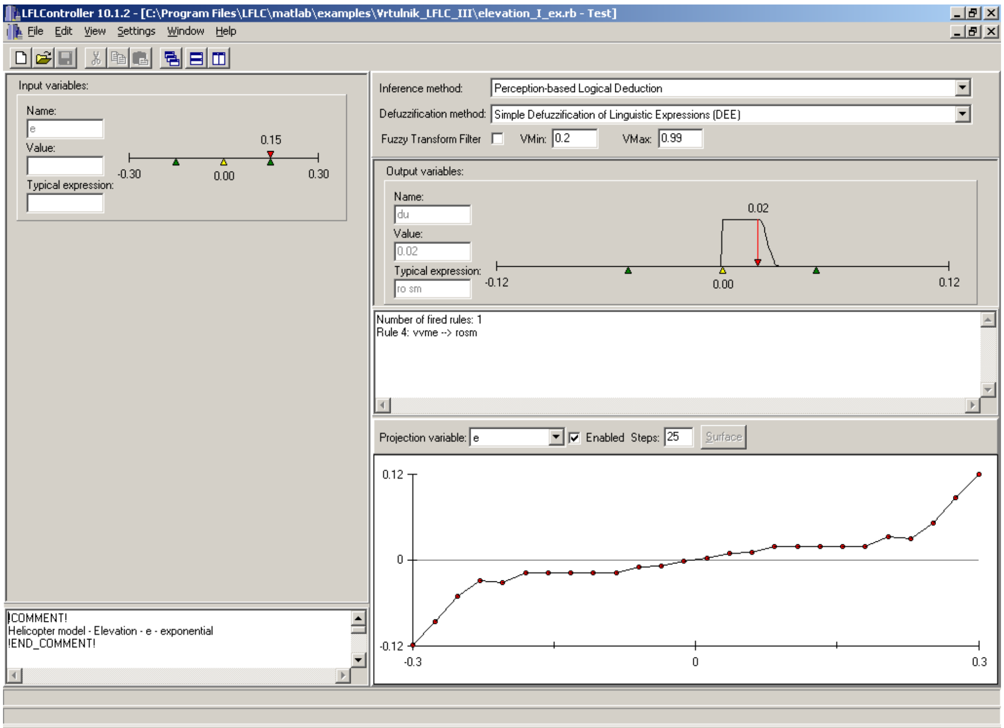

Figure 7. Final LFLC controller behaviour

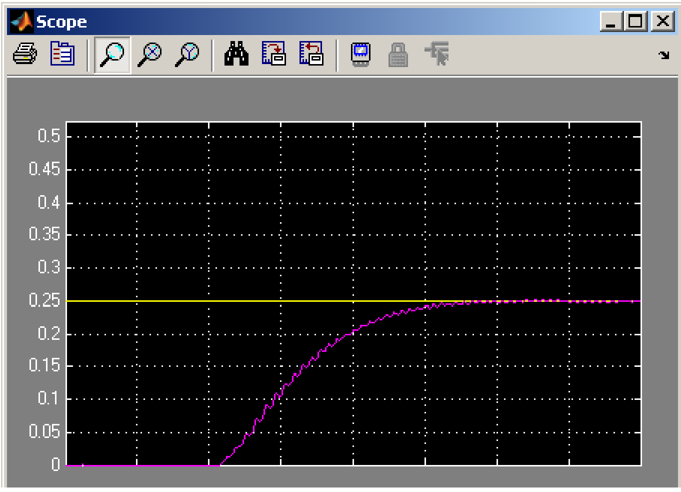

Figure 8. Final LFLC control result

The obtained LFLC control result (Figure 8) represents a very good helicopter control, which could be realised very easily by students who are not experts in Control Theory. Students can also approve how the helicopter will react to the speed control, if the needed translation changes. According to the control theory, the presented controller cannot eliminate a steady-state output error.

3. Pilot model

Next project is typically focused on the speed control. LFLC can be very handy to model the helicopter pilot control strategy. Figure 9 presents the control output with the LFLC controller, developed in the previous chapter (first project).

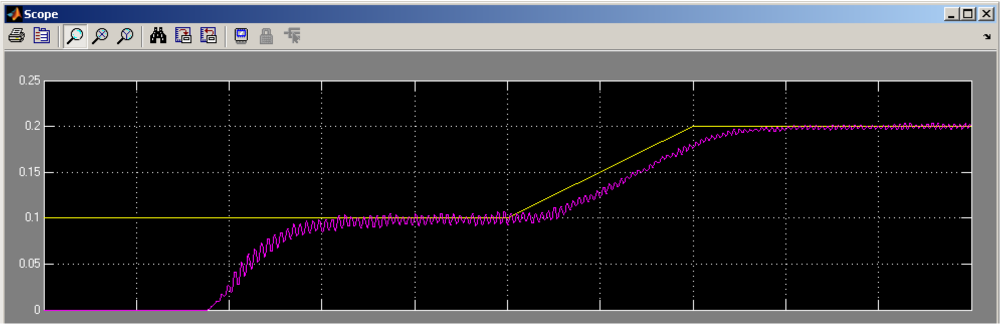

Figure 9. Source control result

Students now construct the second controller which simulates the pilot control strategy. For example the pilot will increase the reaction if the error will persist for a longer time, see Figure 10. This is an example of a very simple strategy which cannot obtain good results, but could be very easily described with help of linguistic values.

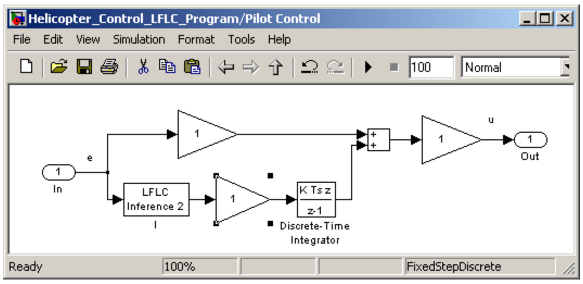

Figure 10. Basic description of a helicopter pilot control strategy

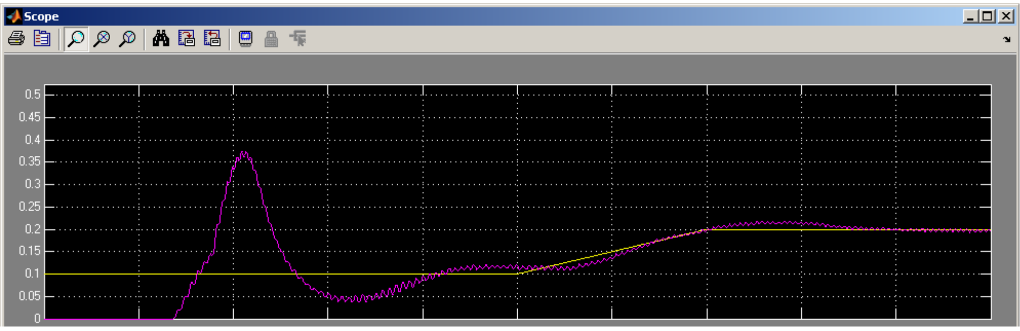

Figure 11. Result of the use of a pilot control strategy

Now can students change the control strategy, especially to eliminate the problem with overshoot in the beginning, see Figure 11, which is caused by a significant dead-zone of the helicopter engine. Both presented examples showed how LFLC can be advantageously used to solve challenging problems of process control.

4. Conclusion

The presented examples of LFLC use have been solved as student projects as a part of problem oriented teaching in the subject “Fuzzy Control” at the University of Ostrava. It is obvious that modern numerical methods such as Fuzzy Logic Control are usable for control of fast technological processes with sampling period 0.01 [s] or less. The Linguistic Fuzzy-Logic Control, developed at the University of Ostrava, is a very helpful tool for control strategy description. The presented results proved how the used technology can help people easily describe control strategy both from technological and pilot’s control strategy point of view. This technology and real models are used as a background for problem-oriented teaching, realised at the Department of Informatics and Computers the Faculty of Science for master students and their collaborative as well as individual final projects. Students learned how to define the control strategy and verify it on a real helicopter model. Having completed these projects, students are able to define control strategies based on LFLC for any similar controlled system.

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Presenter: The paper is presented by Radim Farana

Long Term Role of Coal in the Generation Supply Mix – A System Dynamics Approach

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Abstract

Eskom's Primary Energy Division is mandated with the procurement, development and delivery of primary energy in the form of coal, water, sorbent and biomass to Eskom power stations at the correct quality and the lowest price. Current global outlooks regarding environmental sustainability and climate change, as well varying opinions surrounding available coal reserves, have called for the implementation of renewable energy and low-carbon technologies such as solar photo-voltaic, wind and nuclear, which would represent fundamental changes in direction for Eskom's Generation Division from its business-as-usual production of coal-fired base-load power stations. This paper outlines a system dynamics approach based on systems thinking principles to develop a management flight simulator that provides senior management with a decision support tool to carry out sensitivity analysis on those driving forces that affect Eskom's coal supply based on changes in environmental policies and the generation supply mix over a time frame of 80 years (1993-2073). This systems based approach will support strategic and capacity planning initiatives aligned to a developing economy.

Keywords: *System dynamics, systems thinking, coal, power generation, simulation*.

1. Introduction

Eskom's power generation fleet is comprised of around 41.9GW of nominal capacity of which 85% is comprised of coal-fired electricity generating capacity [1]. This means that the consistent supply of electricity is dependent on a steady supply and availability of mineable coal resources.

It is clear that uncertainty in future plant availability and utilisation due to a potentially diverse generation supply mix as well as life of plant will have major impacts on decisions that need to be made by Eskom's Primary Energy Division (PED) in terms of signing long term contracts to ensure security of future primary energy supply. An over commitment to long term contracts, however, would result in a coal supply which may be surplus to requirements and this must be avoided. It is exceedingly difficult to understand how such fundamental changes would impact on modern systems from a strategic long-term point of view, hence the need for a decision support tool.

A system dynamics methodology was used to develop a management flight simulator for senior management to better understand and explore complex linkages and sensitivities involved in long term coal supply and demand by providing dynamic scenarios/"what if" analyses within calibrated upper and lower values for variables causally linked though feedback loops and time delays inherent in real systems.

1.1. Existing Electricity Generation

The SA energy mix is dominated by fossil fuel based generating technologies with approximately 85% of the current 41.9 GW nominal capacity being coal generation and an expected combined 9600 MW future coal capacity to be provided by Medupi and Kusile stations.

Eskom generation mix includes two hydro-electric power generation facilities (Gariep and Vanderkloof) as well as two hydro pumped storage facilities (Palmiet and Drakensburg) making up 1.4% and 3.4%, respectively, of Eskom's nominal generating capacity.
Eskom's nuclear power-station, Koeberg, provides approximately 4.4% of nominal capacity while the gas power stations (Acacia, Port Rex, Ankerlig and Gourikwa) provide the remaining 5.8% [2].

1.2. New Electricity Generation Options

As has been widely researched, carbon emissions have been identified as a key driver of global climate change, placing great pressure on international power utilities to shift from fossil fuel reliant generation technologies to greener power generation technologies. South Africa has boldly committed to a 34% reduction in emissions from the business-as-usual scenario by 2020 and a 42% reduction by 2025[3]. It is widely believed that renewable energy systems such as wind turbines and solar technologies may provide the necessary capacity whilst mitigating against emissions whilst others believe that only proven technologies for base-load generation such as nuclear power-stations and large scale hydro will assist in achieving the balance between reliability of supply and emissions targets[4]. Either way, the current shortage in reserve capacity implies short and long term strategies to meet demand.

In the short-term, a program of Integrated Demand Management (IDM) was employed to reduce national electricity demand through the implementation of energy efficiency technologies in residential and commercial environments, and as a method to shift demand from peak usage times to off-peak times. These activities serve a dual purpose as the reduction total electricity demand implies that less electricity is generated, meaning emissions levels are decreased.

In the long-term, Eskom commenced construction of two additional coal-fired base load power stations (Medupi and Kusile) each rated at 4800MW installed capacity to meet the increasing electricity demand in a developing economy. This has been met with much debate since it is clear that South Africa needs more capacity but constructing coal fired power stations implies that meeting emissions targets is an even greater challenge (even with emission reduction and clean coal technologies) but also that coal security and availability of supply is critical. requires that Eskom introduce, but it also.

There is a need for a tool to understand not only projections of future electricity demand given the country's economic activity, but to plan for the short and long-term strategies of meeting that demand.

1.3. South African Coal Dynamics

SA has had a historically abundant and cheap coal supply which has provided for around 70% of SA's total primary energy supply, 30% of liquid fuels and 93% of electricity generation [5]. Due to the availability of this resource, the predominant method of power generation in the country has been through combustion of thermal coal.

Eskom PED must secure a sufficient supply of coal to ensure uninterrupted operation of all power stations. This is done through contracts signed with different coal mines for various time periods. The mines agree to supply coal of a particular quality at a certain price, and Eskom must purchase this coal. If power generation shifts away from being primarily coal based, however, either the contracting philosophy will need to change, or new contracts must be negotiated to ensure surplus coal is not bought and paid for without being utilised. In light of this, the contracting periods become a crucial parameter.

The Highveld and Witbank area currently supplies around 84% of SA's coal needs [6] and has significant reserves still available; however, market dynamics have changed dramatically. Eskom used to enjoy the benefits of an 'inward' domestic orientated "buyers" market. It now starts to experience the effects of an open seller's market. Since there are extensive mining initiatives in this area, resource depletion is rapid and the task becomes more technically challenging. Coal miners have to mine shallow pillars, a risky endeavour, in that when done extensively, these mine working can collapse, endangering mine workers [6]. Interest in the Waterberg region has steadily increased [7].

A wide variation in reserve estimates has generated a certain amount of uncertainty surrounding security of future coal supplies. Of particular interest is the comparison between BP's 2008 reserve estimate of 48Gt versus the 2009 figure of 30.41 Gt [8]. The initial figure was obtained from assessments of SA coal reserves done in the 1980's by the South African Geological Survey, while the updated figure was based on a reassessment done in 2003-2004 by the Minerals Bureau under the Department of Minerals and Energy which severely downsized the reserve estimates [8]. These estimations do not take into account the differences between qualities of coal sources.

Coal price is by no means a value that can be fixed. Ian Hall, chairman of the Coal Roadmap steering committee published an article on ESI Africa stating that transportation of coal by rail from the Waterberg region could cost up to 200 Rand/tonne extra on top of a plausible actual cost of 230 Rand/tonne giving a final value of 430 Rand/tonne [4]. This increase will dramatically affect the economic feasibility of more expensive generation options.

Similarly to increased prices, the introduction of a CO_2 emissions tax will goad worst performers into pursuing more expensive mitigation strategies such as Carbon Capture and Storage (CCS) or simply switching to a different primary energy source like nuclear power, renewable energy or potentially, shale gas, which would previously not have been a cost effective option.

2. The System Dynamics Approach

In light of the uncertainties and numerous options mentioned above, the need for a simulation environment to test assumptions and gain a greater understanding was apparent. Through the development of a system dynamics management flight simulator, the key driving forces affecting the coal supply and demand climate in Eskom can be understood.

Modelling the impact of future generation scenarios as well as policy decisions and coal costs can have a significant impact on the direction that must be taken by the business with respect to the future generation mix. Eskom is currently reliant on a steady supply of coal as this resource has been readily available in the past. Predictions of future availability and cost of coal, however, vary greatly and there is a need to understand this system more effectively. Lead times to construct and commission new power stations, as well as those associated with the development of new coal sources and associated infrastructure are of particular relevance to support long term planning decisions.

2.1. Key Variables and Concepts

Aside from the need to diversify the energy mix for environmental and social reasons, significant uncertainties surrounding SA's future coal supply exist. There is a need for a simulation model which will outline the impacts both, financial and otherwise, arising from decisions surrounding future generation mix. Policy and decision makers will then have a tool to aid understanding of a complex system which involves many variables over which Eskom can exert no control. Figure 1 shows a system architecture map describing this simulator.

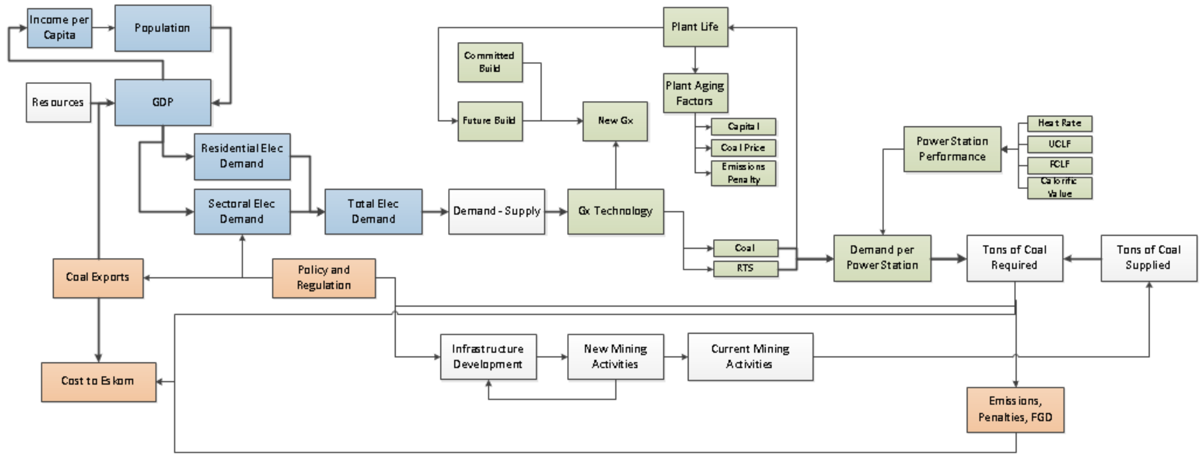

Figure 1, System Architecture Map

The system architecture map shows some of the high level interactions built into the simulator and provides a "birds-eye" view of the system being modelled. Following the section highlighted in blue, electricity demand is seen to be calculated using GDP and population. The demand is split into a residential and sectorial electricity demand as these would respond differently to GDP and population.

The total electricity demand defined as the sum of residential and sectorial demand is parsed through a Supply-Demand section shown as a central grey block, this section distributes the electricity demand between available power generation technologies. While only Coal Return To Service (RTS) generation options (previously mothballed power stations) are specifically mentioned in this diagram, all large scale generation options are considered for future build. Some of the variables which impact on the coal electricity supply are shown as power station performance factors and life of plant.

After an electricity supply per power station is calculated, the coal demand for each of those stations is also calculated. These individual amounts translate into a total Eskom coal demand and is supplied by current mining activities which are in turn influenced by new mining activities and infrastructure development such as road to rail migration.

Policy factors must also be considered and these are shown in red. Emissions penalties must be affected by tons of coal used and this value, as well as coal exports, would influence the total cost to Eskom. Additional policy decisions such as declaring coal a strategic resource are considered on a high level.

2.2. Causal Loop Diagram

Causal loop diagrams are utilised in the system dynamics methodology in order to outline and frame the problem to be simulated. Stakeholders and subject matter experts are invited to provide insight into the system at this point in order to advise which interactions they feel could be particularly significant or would be of particular interest to them.

While it is always difficult to intuitively understand particular sensitivities of interacting variables in complex systems without some form of simulation tool, it is possible to draw on the experience of knowledgeable individuals to begin mapping out cause and effects relationships.

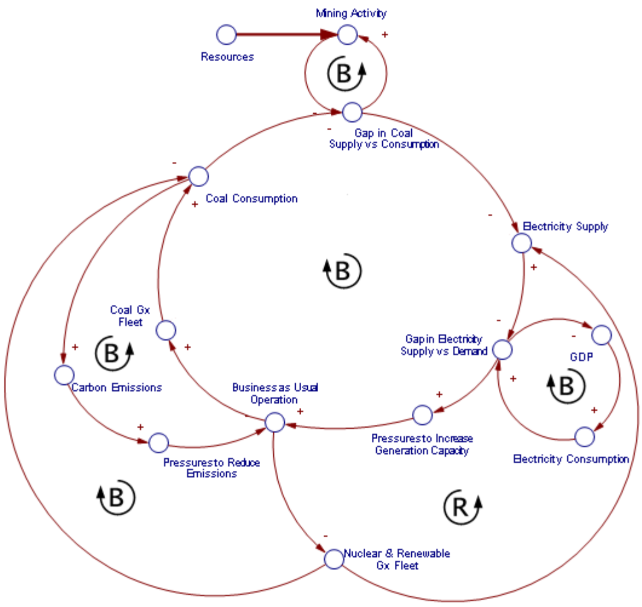

Figure 2, Causal Loop Diagram

Since the focus of the project is to understand Eskom's coal requirements and methods of meeting this need in the long term, the central variable "Gap in Coal Supply vs Consumption" is an excellent starting point to explain the dynamics in this project. A change in this variable causes both a reaction and a consequence, the former being a change in mining activity, including both increased capacity recovered from existing coal mines, as well as the development of new coal sources. The relationship is positive indicating that an increase in the initial gap causes an increase in mining activity. This increase in turn closes the gap in coal supply and demand, closing the first balancing loop. It is important to note the presence of a limiting factor affecting the mining activity, namely the amount of coal resources available in South Africa.

The consequence of an increase in the gap between coal supply and demand is a reduction in electricity supply, given that South Africa's power generation fleet is primarily coal driven. This reduction causes an increase in the gap between electricity supply and demand, increasing the pressures to add to the existing generation capacity.

South Africa has always enjoyed cheap and abundant coal and has developed experience in the construction and operation of coal-fired power stations. As such, it is logical that increased pressures would lead to a business as usual response, namely the construction of additional coal based generation. It follows that coal consumption will then increase, increasing the gap between coal supply and usage and closing the second balancing loop.

It should be noted that while it appears that a linkage could be formed between increased coal-fired generation capacity and electricity supply directly, this linkage is already made through the coal supply and demand dynamic. Power generation using thermal coal is dependent on the availability of that coal and simply having the power station with no means of operating it, could not increase electricity supply.

It is understood that electricity consumption must be linked to a country's economic activity and as such, an increased gap in electricity supply versus demand will cause a reduction in economic growth, measured through GDP. This reduction in growth is followed by a decrease in electricity consumption, closing the initial gap and forming the third balancing loop.

Coal consumption cannot increase unchecked as it results directly in increased carbon emissions and through environmental legislation and commitments made by South Africa to the Kyoto protocol, increased pressures to reduce these emissions by deviating from business as usual operations. Once this fourth balancing loop has been closed, the production of nuclear and renewable power generation facilities will both reduce coal consumption and increase electricity supply, closing the fifth and final balancing loop and the only reinforcing loop respectively

2.3. Simulation Software

The standard software utilised by Eskom's System Dynamics Centre of Expertise is Stella. Stella is an object oriented programming environment allowing the user to drag and drop elements representing certain variables in a system and then define values or equations for these variables.

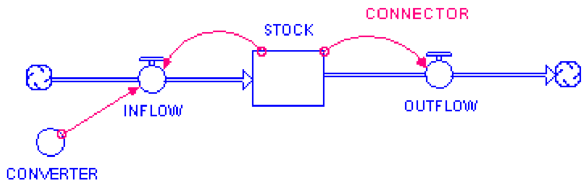

Figure 3, Stella Modelling Elements

Figure 3 shows the elements used in Stella. The stock accumulates or decreases over time and represents an integrator. The inflow or outflow is the rate of change into or out of a stock and represents a derivative; these flows can be in a single direction or defined as bi-flows (able to flow in two directions). The converter performs any additional mathematical algorithms and conditional statements such as IF…THEN ELSE.

Construction of a simulator involves defining a number of objects as variables in the system with state variables being defined as stocks. Variables are then physically linked using the pink connector lines which represent a flow of information. An equation defined in a variable may utilize any other variables physically connected to it. Table 2 shows examples of some stocks, flows and converters used in the simulator.

Table 2, Stocks, Flows and Converters Used in the Coal Simulator

Stocks	**Flows**	**Converters**
Coal Mines	Mining Rates	Power Station Efficiency
Population	Population Growth	Coal Calorific Value
GDP	GDP Growth	GDP Growth Rate
Total Generation Capacity	Decomissioning	
	New Build Power Stations	

3. Constructing the Simulator

In order to capture sufficient detail correctly model complex interactions, this simulator covered the electricity production value chain from electricity demand driven by population and Gross Domestic Product (GDP) growth, through electricity generation including current and future technologies all the way to primary energy requirements in the form of thermal coal only.

It is a distinct possibility for simulators such as these to suffer from "scope-creep". To ensure the simulator is well defined and covers enough areas to capture the essence of the problem to be investigated but not so much as to cloud the issue and make the task of simulation one that is impossibly large, a model boundary chart is drawn up and agreed upon by all parties involved. Table 3 shows the model boundary chart for this simulator.

Endogenous variables are variables that are physically calculated by the simulator, exogenous variables are utilised but are obtained from external sources and finally excluded variables are self-explanatory.

Table 3, Model Boundary Chart

ENDOGENOUS VARIABLES	EXOGENOUS VARIABLES	EXCLUDED VARIABLES
Electricity Demand	GDP Growth	Coal Quality (excl. CV)
Generation Capacity	Coal Resources	Energy efficiency drives
Reserve Margin	Cost of Coal	Mining methods
Coal Consumption	Calorific Values	Coal Quality (excl. CV)
LCOE	Heat Rates	
UCLF	PCLF	

This simulator uses three patterns of GDP growth as shown in the Integrated Resource Plan (IRP) 2010 to project electricity growth up to 2073. The projected high, medium and low growth rates are 6%, 4.1% and 3.4% respectively. A simulation cut off year of 2073 is chosen in order to encompass the full life of Eskom's committed new generation build, namely Medupi and Kusile.

A demand scheduling logic based on least cost R/MWh to generate a set amount of electricity is used to allocate shares of the total projected electricity demand to each type of generating technology, i.e. nuclear generation capacity must take up as much load as possible first seeing as this type of power station is expensive to construct but relatively cheap to run.

The same scheduling logic allocates a certain share of the electricity demand to coal powered generation. At this point the coal generation fleet is disaggregated into a per power station level. Power station availability as determined by equation 1 defines how much electricity the coal fleet could in fact supply.

$$EAF = 1-(PCLF+UCLF+OCLF) \tag{1}$$

EAF = Energy Availability Factor
PCLF = Planned Capacity Loss Factor
UCLF = Unplanned Capacity Loss Factor
OCLF = Other Capacity Loss Factor

The electricity supplied by a power station in MWh is converted a value in GJ using a conversion factor of 3.6 and finally, the primary energy requirement for each power station is calculated using its thermal efficiency.

3.1. Simulating Coal Supply

In order to determine the Eskom's primary coal requirement going forward, the energy requirement variable for each power station is linked to possible coal supply variables representing individual coal mines. The coal mine variables contain data for estimated coal reserves in Mt, Calorific Values (CV) in kJ/kg, cost in R/t and finally, maximum mineable rate per annum in Mt.

Each coal mine is defined as a stock variable and its initial condition is its available reserves. As a power station's energy requirements pass through the simulator to the coal mine variables, the energy requirement in GJ is converted into a tonnage of coal required to meet that demand using the CV of coal at that mine. It follows that as coal is utilised in this way, the stock/reserve depletes until no more coal is available from that mine.

As the simulator runs, an energy flow is established as mine reserves depleting and electricity supplied. The simulator is programmed in such a way that an electricity shortfall may arise for one of three different reasons:

1. **Demand outstrips supply** – In this case there is simply not enough generation capacity available to supply the required amount of electricity. The future generation build defined by the user in the simulator must be r-looked at and additional power stations must be defined.
2. **Depletion of coal reserves** – If the SA reliance on coal into the future is so great as to cause available coal reserves defined in the model to deplete completely, no primary energy will be

available for conversion into electricity. Either the mix of power station types must be changed or additional coal sources must be explored.

3. **Demand outstrips mineable** rates – Finally, the demand for primary energy in the form of thermal coal for one year could outstrip the capacity that all of the defined mines can supply in one year. As above, either the energy mix must change or additional resources must be explored.

4. Scenarios

While this simulator is not yet complete, it can be utilised to generate several interesting and useful scenarios, explained below.

4.1. Emissions Reduction Targets

In this scenario, the SA energy mix is considered as a percentage value. The simulator uses the IRP 2010 build plan as a default, with any changes in energy mix done primarily on a least cost merit order. The projected build capacity is capped by the future electricity demand projected using the GDP growth scenarios of 3.4, 4.2 and 6 %. Table 4 and Figure 4 show the base case energy mix i.e. the simulator is allowed to run based on its default inputs.

Table 5 and Figure 5 represent a scenario in which an emissions reduction target has been imposed on the simulator. The imposed target is 34%. A value of 34% is used to correspond with SA reduction commitments.

Table 4, Base Case Energy Mix

Year	Coal %	Nuclear %	Renewable %	Kerosene %
2020	88	4	0	8
2025	86	4	4	6
2030	65	18	12	5
2035	41	17	39	3
2040	42	19	36	3
2045	30	22	47	1
2050	31	19	50	0
2055	26	17	56	0
2060	22	20	58	0

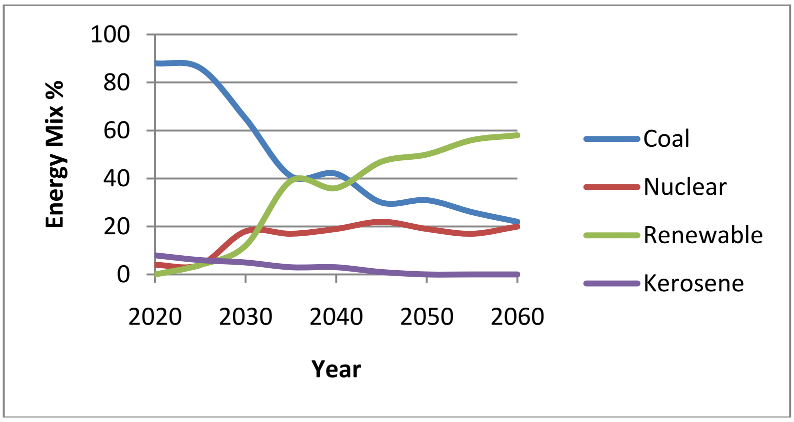

Figure 4, Graph of Base Case Energy Mix

Table 5, 34% Reduction Target

Year	Coal %	Nuclear %	Renewable %	Kerosene %
2020	88	4	0	8
2025	86	4	4	6
2030	65	18	12	5
2035	41	17	39	3
2040	32	19	46	3
2045	26	26	47	1
2050	23	23	54	0
2055	19	21	60	0
2060	15	22	63	0

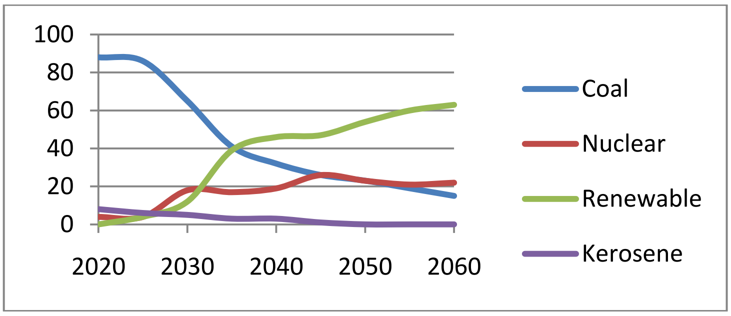

Figure 5, 34% Reduction Target Energy Mix

A significant reduction in coal fired power in the total energy mix can be seen in 2040 with a reduction from base case of a full 10%. This is due to six power stations making up the existing coal fleet being decommissioned in the years between 2035 and 2040. In the base case, additional coal fired power stations would be constructed in accordance with the IRP 2010 to account for this loss, but with the imposed emissions reduction target, the simulator shows that the most cost effective method of dealing with the loss is to construct renewable energy.

The IRP build plan states that most of the initial renewable energy expansion will be solar technology with wind becoming prevalent in later years. Solar power generation can be an especially water intensive activity with areas of highest solar irradiation occurring where water is scarce. Water is required to clean solar panels as well as acting as an energy carrier in the Rankin Cycle which every solar technology aside from solar photo-voltaic employs.

As water needs increase beyond a pre-defined set point, the simulator builds some additional nuclear power to account for the ever declining coal fleet. Nuclear power stations may be built along the coast and can utilise sea water for cooling making it a less water intensive technology and this can make it an attractive option despite a higher expense.

4.2. Reserve Margins

The following scenario looks at the energy reserve margin and reliable reserve margin associated with a renewable heavy or nuclear heavy energy mix. The difference between these two is based on the low capacity factors seen in renewable energy generation technologies. While a renewable heavy energy mix may have a large capacity in MW, its ability to supply energy is lower than a coal or nuclear heavy mix.

Using the base case energy mix shown in Table 4, Figure 6 shows the calculated energy reserve margin and reliable reserve margin.

The years between 2015 and 2045 still contain a large portion of coal and nuclear power and show a high energy reserve margin. After 2045 the renewable technologies begin to dominate the energy mix and the reliable reserve margin calculated from the MW availability is seen to be lower than the actual energy the system can supply based on capacity factors.

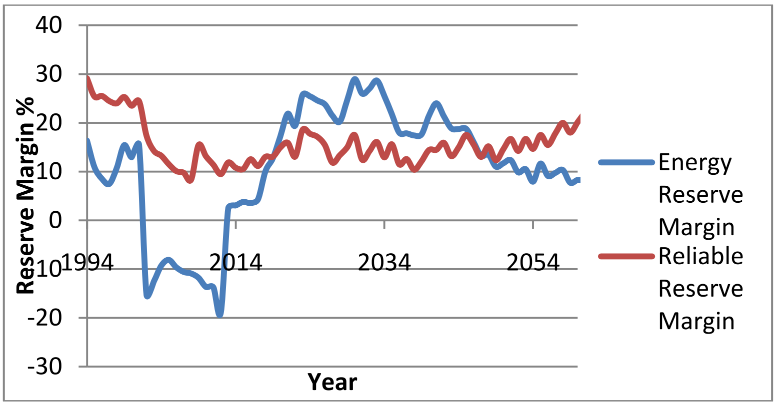

Figure 6, Energy and Reliable Reserve Margins for Base Case

Figure 7 shows a case where all the options to build renewable energies have disabled from the simulator, so only coal, nuclear and kerosene is available. While this scenario does focus on an extreme situation, it serves to illustrate what an energy mix made up entirely of high availability base load generation would look like in terms of reserve margin.

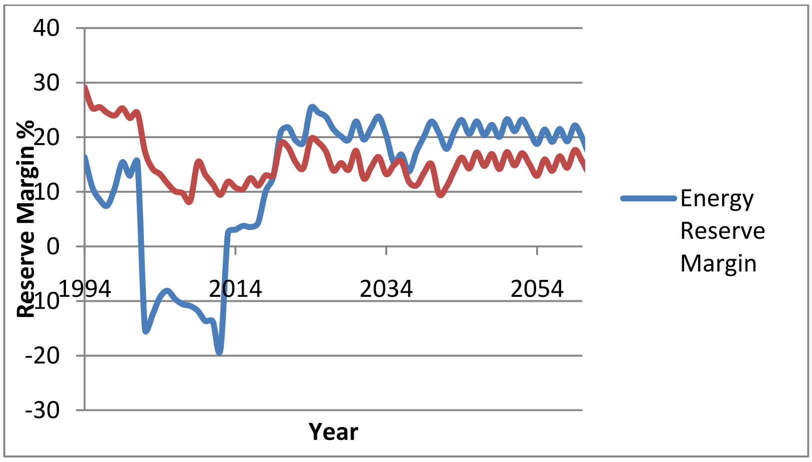

Figure 7, Energy vs Reliable Reserve Margin with No Renewables

This graph clearly illustrates an energy reserve margin which sits consistently and comfortably above the reliable reserve margin, a picture which corresponds with a stable energy mix.

5. Conclusion

While the simulator is still in development, two useful scenarios have been illustrated. It follows that these scenarios may be used to calculate not only reserve margins and associated emissions, but also future coal requirements in tons once final model structures have been completed.

The ability to quickly and easily perform dynamic scenario analysis allows senior management to engage in interactive strategic dialogues and in this way, system dynamics simulators act as decision support tools to the larger Eskom business.

Future work will include the completion of the simulator to calculate final coal requirements, and to show the impacts of various policy decisions such as the declaration of coal as a strategic resource, the influence of Carbon tax and Eskom's possible need to pay export parity coal prices.

It is important to note that while the simulator is based on actual figures and calculations in order to generate graphs as accurately as possible, it is the patterns of behavior that are of most importance. The graphs show trends of behavior projected into the future to allow users to quickly identify areas of growth or decline, and to understand what would cause that behavior.

7. Acknowledgements

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Knowledge representation for rules-based expert systems

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Abstract

Rule-based knowledge representation is considered the most popular method to build expert systems. Traditionally, conditional sequence progression often fails to reflect correct thinking in some special areas - for example in medicine where "characteristic – symptom" or "characteristic - disease" fail in incorrect diagnosis. So the pair "characteristic – the influence on the result" is more reliable for a favourable solution; in this case the modified form of the rule is: IF condition 1 and condition 2 and condition 3 and … influences inf on f_k where inf is the linguistic value of the influence; f_k - is the resulting fact of the set F. Linguistic value inf can be interpreted with the help of the expert, by using fuzzy logic or so called indeterminacy. This paper describes a method of comparative evaluation of parameters for creation of a knowledge base of modified rules by considering factual influence. As examples Kordex, for urgent cardiology and Infosafety, for prognosis of company information security and GazeXP regarding turbines, are expert systems considered.

Key words: *Expert system, knowledge base, rules, mutual influence of facts.*

1. Introduction

Expert systems as artificial intelligence provide important value allowing formalisation of human knowledge for decision making. Rules set the tone, and universalism, as any formal system using symbols, can be developed with post rule-based systems [1], moreover, a human idea can be represented with rules.

Knowledge base K has set of rules

$$R = \{r_1, r_2, \dots, r_n\} \tag{1}$$

r_m: *IF* f_i *and* f_j *... and* f_n *THEN* f_k,, where F is set of facts f_i.

In practice, however, more common situations exist where it is impossible to use the rule (1). A typical example is task of prognosis in medicine. Many medical algorithms relate *"characteristic – symptom" or "characteristic disease" usually do not afford correct diagnosis.*

Symptom characterizes the state of an organ or entire system, not the state of the disease or its prognosis. In cardiology, recurrent difficulty to treat chest pain at rest, may be a manifestation of a pessimistic prognosis of unstable angina; coronary artery thrombosis; myocardial ischemia probably loom. Also, the presence of similar symptoms for several complaints and myriad combinations of differing symptoms means a substantial increase in knowledge base rules.
For medical practices a more useful chain would be "symptom - the impact on the syndrome - the disease (prognosis of the disease)", when the syndrome refers to features outlining state of organ or system.

2. Comparative Evaluation of the Influence of Parameters

In cases where the rule of the form (1) can not be applied to the formalisation of knowledge, a method of comparative evaluation of the influence of parameters is proposed. Human concept thinking normally works linearly, a pattern appropriate to construct a domain model. Moreover, excess information is always available to an expert and could be weighed, taking into account influence (the fact) on the development of the syndrome (intermediate or final determination).

Thus, it was proposed to use rule type:

rm: fi IF THAT AFFECTS ON inf f_k, (2)

where *inf* is a level of the influence of the fact f_i on f_k. and takes the values of the term-set D

D = {"high (strong)," "moderate," "low (weak)," "almost there"} (3)

Influence can be negative (reducing the possibility of the fact f_k), and positive (reinforcing the possibility of the fact f_k).

A well-proven knowledge model consists of three levels (input, intermediate, output); a qualitative model of knowledge representation (Figure1) is similar with a three-layer perceptron (algorithm) where an intermediate layer represents the syndromes.

In the structure of rule-based knowledge base, see Figure 1, $X = (x_1, x_2, \dots, x_n)$ - a set of input facts; $Y = (y_1, y_2, \dots, y_m)$ - a set of intermediate facts (syndromes); $G = (g_1, g_2, \dots, g_k)$ - a set of the goals of expert system.

Mathematically, this means each intermediate and output variable are defined as the sum of the respective weights (w_{ij}, v_{ij}):

$$y_j = \sum_{i=1}^{n} w_{ij} \,; \quad g_r = \sum_{i=1}^{m} v_{ir} \,, \tag{4}$$

If the total value of y_j and g_r exceed certain limits l_{1j}, l_{2j}, respectively, the output can be considered reached. Values y_j and g_r, and l_{1j}, l_{2j} may be presented in the form of linguistic variables ZN, taking values of a set of D (3) or could be defined by the expert.

ZN is defined as a set <T, D, X, G, M>, where

T - the set of its values (term set) representing the names of fuzzy variables, for which a set X serves as a domain. The set D is called the base term set of linguistic variables;

G - syntactic procedure that allows handling the elements of term-set D, in particular, to generate new terms. The set D ∩ G (D), where G (D) - generated a lot of terms is called the extended term set of linguistic variables;

M – semantics procedure that allows conversion of the new value of the linguistic variable formed by procedure G, a fuzzy variable; used to form the corresponding fuzzy set.

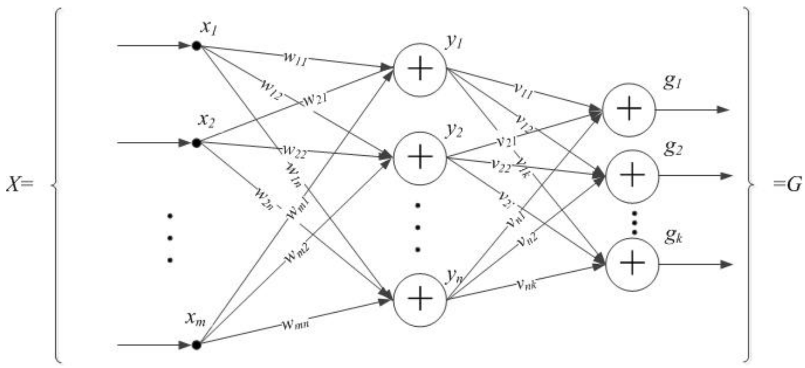

Figure 1: Structure of knowledge base formed with comparative influence of parameters

For the development of expert systems in urgent cardiology, in the process of building rule-based knowledge base (RBKB) expert answers are required to questions of the qualitative influence of impact of each symptom on development prognosis. "What is the contribution a particular feature (maybe, lack of a sign) makes in the expression of a specific syndrome?" i.e. must subjectively (qualitatively) seta load factor. Moreover, the same feature changes in magnitude and sign for "input" to different syndromes (intermediate data), which in turn affect target values. For convenience, it is recommended construction of a knowledge base – see Table 1. The presence of stable chest pain at minimum effort strongly influences the severity of *stenosis* of the coronary arteries; but does not affect the severity of spasms, has little influence on development of thrombosis and has a moderately negative effect on myocardial adaptation to ischemia.

Table 1: Formation of a matrix of weighting co-efficients

.	y_1	y_2	$.y_i$ . .	y_{n-1}	y_n
x_1	w_{11}	w_{12}	w_{1i}	w_{1n-1}	w_{1n}
x_2	w_{21}	w_{22}	w_{2i}	w_{2n-1}	w_{2n}
…					
x_{m-1}	w_{m-11}	w_{m-12}	w_{m-1i}	w_{m-1n-1}	w_{m-1n}
x_m	w_{m1}	w_{m2}	w_{mi}	w_{mn-1}	w_{mn}

In general, the model of knowledge has *z* levels, however, the most effective method works for one found in the intermediate layer. Application for the formation of a product knowledge expert system can significantly reduce dimensionality compared to conventional methods and saves time time. [2]

3. Application of Comparative Influence of the Parameters

Prognosis of myocardial infarction is a major problem faced by modern medicine. Methods of comparative evaluation of the influence of the parameters have been successfully applied to the expert system Kordex [2]; which forecasts development of unstable angina and determines risk of complications from anti-arrhythmic therapy. It allocates 196 input facts, six intermediate facts (syndromes) defining unstable angina and risk predicts myocardial infarction and treatment (elements of G). Also reviewed are: degree of atherosclerotic narrowing of the coronary arteries, probability of coronary artery thrombosis, myocardial adaptation to ischemia, myocardial oxygen demand, tendency to spasm of the coronary arteries and, the rate of increase of *stenosis* of the coronary arteries.

Rules relating to the field of direct prediction and treatment assignment are:

NA: IF coronary vasospasm is high, then it moderately increases the risk of heart attacks, greatly increases need for ingesting of a calcium agent, reducing need for beta-blockers.

PT: IF sympathetic-adrenal system action is high, it greatly reduces the effectiveness of therapy.
Adequate approach to the formation of a base through quality selection of facts (syndromes) meant only a base of 416 suggestions (3). Kordex, however, with its rule-based system (2) provided 4 600 [2] and demonstrated its efficiency for prognosis of unstable angina during tests at the State Medical Clinic of Saratov Medical University.

The method has also successfully built a knowledge base of an expert system InfoSafety for forecasting threat to information security of an enterprise [2, 3], including taking into account social engineering and definition of measures to prevent threat. Total volume of rules (3) was 152.

Table 2: Impact of facts on input data in the expert system InfoSafety

The Value of the Input Fact	**Output fact: the motivation of staff to participate in the security policy**	**Output fact: the threat of social engineering**
Ordinary employee	Greatly reduces	greatly increases
Manager	Moderately increases	moderately reduces
Age older than 50 years	slightly decreases	strongly reduces
The presence of a security policy	Moderately increases	strongly reduces
Knowledge in the face of all the IT service staff	Moderate increases	moderately reduces
Possibility of using other people's logins & passwords	Greatly reduces	greatly increases
Using Internet in the office		moderately increases
Reading unfamiliar e-mail or spam		strongly increases
Good relations with colleagues and superiors	strongly increases	moderately increases

Examples of productions of the expert system InfoSafety:
R45: "Good relations with superiors and colleagues" greatly increased staff motivation to participate in a security policy.
R46: "Good relations with superiors and colleagues" moderately decreased risk of social engineering.
R59:: "Staff participation in a development of tasks management policy" greatly increased staff motivation to welcome a security policy and moderately reduced risk of social engineering.

Note: The comparative influence of the parameters was successfully applied during expert handling of formalisation of knowledge and its multi-dimensional data processing methods used to extract the most informative features and a description of their effect on other symptoms.

The method was used also in development of the expert system GazeXP for detecting failure in gas turbines. Key failures were detected by neural network and reasons determined by the described method.

4. Conclusions

Comparative influence of parameters demonstrated its efficiency for development of rule-based expert systems; using Kordex, InfoSafety and GazeXP..

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Different Perspectives on Smart Grid and Lessons for South Africa

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Abstract

The potential of smart grid projects it as a silver-bullet to electric power system challenges. This is because smart grid is a core concept in sustainable electricity generation and consumption. The era when electric grid refers only to all the high voltage lines plus the big transformers and related equipment that form the transmission system is over. Each country or region has a peculiar energy mix and challenges. South Africa's dwindling reserve margin, high CO_2 emissions and future energy mix are outstanding reasons for her smart grid deployment. Who receives the credit for the smart grid neologism is contentious and smart grid definition is diverse. However, there is a consensus on its attributes or benefits. Therefore, South Africa's proper education of her electrical consumers on the fundamental meaning of smart grid and accruing benefits will enhance her consumer engagement – a lesson from some regions or countries where consumers opposed smart grid. The establishment of South Africa Smart Grid Initiative (SASGI), and Eskom's commencement of deploying a hybrid smart grid model are proofs of the country's commitment towards smart grid concept. Consequently, she is presented with the opportunity to "leap-frog" and enhance the relevant proven applicable smart grid solutions.

Keywords: *Reserve margin, Carbon emission, Smart grid.*

1. Introduction

Electricity is the commonest form in energy in most aspects of life. So, electricity is a product that has become the lifeblood of modern life resulting in its being a major criterion in grading economies. It is traditionally generated in large centralised power stations and transported at high voltages through long distance to load centres for distribution. In South Africa (SA) the generators in the power stations produce electricity at about 20 kV. The high voltage transmission system in Eskom comprises 132 kV, 275 kV, 400 kV and 765 kV [1]. Eskom is a South African government authority mandated to generate, transmit and in some cases, distribute power. All the high voltage lines plus the big transformers and related equipment form the transmission system, also known as the National Grid or simply "grid". This meaning of grid has been invalidated by the smart grid concept in which grid transcends transmission system. However, electricity symbolised by the electric grid was cited by the National Academy of Engineering as the supreme engineering achievement of the 20th century [2] because if *any* of its elements were removed our world would be a very different place – and a much less hospitable one.

Although the grid has witnessed many innovations and improvements over the last century, its basic design has remained the same from the days of Edison and Tesla in the 1880s: centralised generation through a one-way transmission and distribution system to consuming devices that have no information about the cost of electricity or whether the grid is overloaded. Reliable and high quality electric power is becoming increasingly important given the pervasive application of electronics and microprocessors. This justifies the urgent need to modernise the grid. Efforts to modernize the grid are motivated by several goals [3] such as:

- To make the production and delivery of electricity more cost-effective.
- To provide consumers with electronically available information and automated tools to help them make more informed decisions about their energy consumption and control their costs.

- To help reduce production of greenhouse gas emissions in generating electricity by permitting greater use of renewable sources.
- To improve the reliability of service.
- To prepare the grid to support a growing fleet of electric vehicles in order to reduce dependence on oil.

The second and third goals seem currently more pertinent to SA. Firstly, the challenge posed by reduced reserve margin in SA's power system really manifested recently. Since 2007, Eskom has experienced a lack of capacity in the generation and reticulation of electricity [4] which resulted in the first quarter of 2008 blackouts experienced in the country and the resultant SA's economic damage. As a result the economic growth of the first quarter of 2008 fell to 1.57% from 5.4% in the last quarter of 2007. At the peak of the crisis, the generation net reserve margin fell below 10% – well below the conventional industry benchmark of at least 15%. The main reason for the 2007-2008 energy crisis was the imbalance between electricity supply and demand.

Secondly, according to an IEIA (International Energy Information Administration) 2009 study, SA's per capita emissions are 9.18 tonnes of CO_2 [5]. The study estimated that SA is the 12th highest CO_2 emitter globally with China as the greatest contributor while United States (US) is in second position. While SA only contributes 1.49% to global CO_2 emissions, its per capita emissions are high relative to many countries. Figure 1 shows SA's per capita CO_2 emissions in relation to other BRICS (Brazil, Russia, India, China and South Africa) member countries and the US. It is evident from the figure that SA exceeds the world average of 4.49 tonnes of CO_2 per capita and is higher than China, Brazil and India. The study further re-echoes that SA is Africa's largest emitter contributing over 40% of Africa's total CO_2 emissions. SA's energy intensive economy and high dependence on coal for primary energy are actually responsible for her emission status.

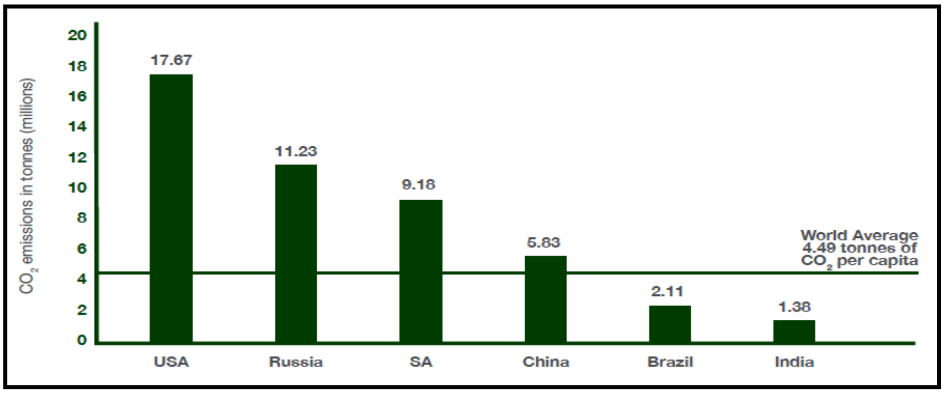

Figure 1. SA's per capita CO_2 emissions relative to other BRICS member countries and the US [5]

Undoubtedly, with an increasing demand in energy predicted and growing environmental concerns about fossil fuel based energy systems, the development of large-scale renewable energy supply schemes is strategically important for increasing the diversity of domestic energy supplies and avoiding energy imports while minimising the environmental impacts [6]. Figure 2 shows a diagrammatical representation of SA's future energy mix based on her Integrated Resource Plan (IRP). The IRP aims to balance affordability with the need to reduce carbon emissions and ensure security of supply.

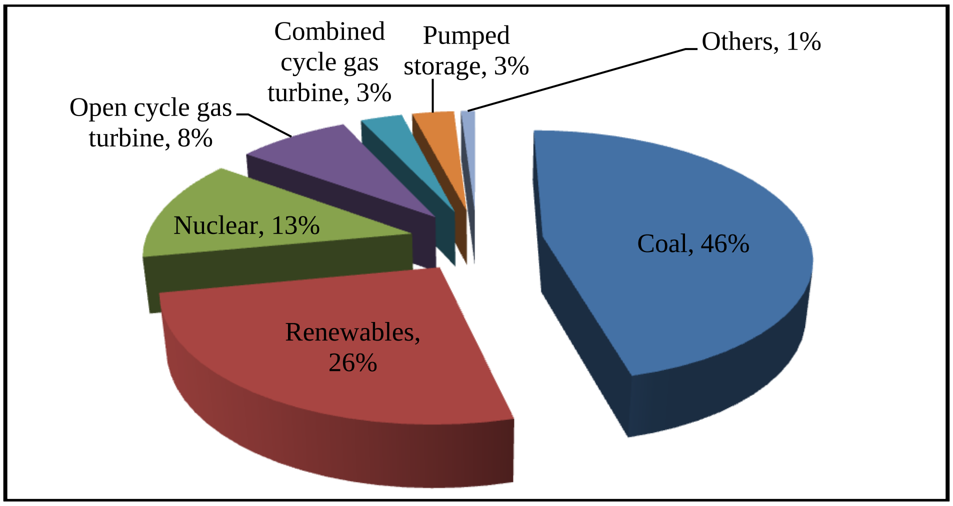

Figure 2. SA's future energy mix by 2030 [7]

This work is aimed at reviewing the different perceptions of smart grid (grid modernisation) and the inherent lessons for SA. Such perspectives include the coinage, concept and definition of smart grid; and also comparisons of smart grid developments in some regions or countries.

2. Smart grid neologism

There is an apparent confusion on who coined the phrase "smart grid" and the date. Literature is replete with credits being given to Dr. Massood Amin for the smart grid neologism without a consensus on the date. The dates mostly cited are 2003, 2004 and 2005 [8 - 10]. Equally Andres E. Carvallo is credited with smart grid coinage in 2007 [11], [12]. But Andres Carvallo defined smart grid on March 5, 2004 and with John Cooper built the very first smart grid in the United States at Austin Energy – what they now call a first generation smart grid, or Smart Grid 1.0 – and have documented their unique experiences from 2003 to 2010 [13].

However, smart grid was named in US while the concept emerged in Europe [14]. The US Energy Independence and Security Act (EISA) of 2007, particularly with article XIII, started the era of an official use of the term "smart grid" to designate future expansion of the electricity grid [15]. Therefore, over the last few years, the term ''smart grid'' has taken the electric power industry by storm, with its use being further cemented in the power industry lexicon with the launch of the IEEE *Transactions on Smart Grid Journal* in 2010 [16].

This seeming controversy on "smart grid" coinage is common in science and technology. Consequently the smart grid historical perspective should be devoid of the historians' holistic approach because of the apparent differences in the dates of some of the major scientific or technological feats, as noted in [17].

3. Smart grid concept and definition

The smart grid concept combines a number of technologies, end-user solutions and addresses a number of policy and regulatory drivers [16]. An attempt was made to characterise some key features of future grid development, such as the introduction of extensive communication, computational and sensing capabilities. Also there was a particular emphasis on expanding the ability of humans, whether in the role of grid operators or users of electricity, to be able to receive new information concerning grid conditions and to respond to this additional information with various actions at their disposal. As the attributes of the new grid were expanded, it became more difficult to capture all of this in simple terms; thus many interpretations of what smart grid really means have emerged [14]. It is probably safe to say that there are as many definitions of "smart grid" as there are smart grid projects, experts, or practitioners [18]. The definition of a smart grid also varies owing to the complexity of power systems [19]. A smart grid vision is illustrated in Figure 3.

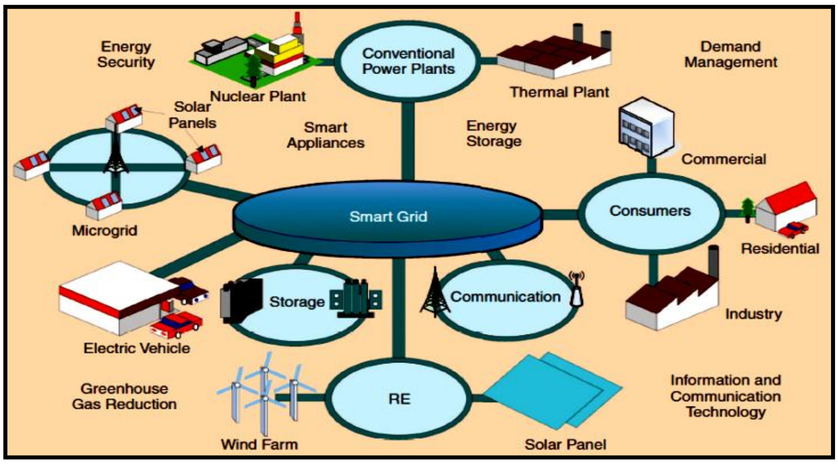

Figure 3. The future electric grid [20]

It should be noted that smart grid can be defined in multiple ways including by its technologies, its functionality, and its benefits. Below are smart grid definitions by European Union (EU) and US respectively [21]:

- A Smart Grid is “an electricity network that can intelligently integrate the behaviour and actions of all users connected to it – generators, consumers and those that do both – in order to efficiently ensure sustainable, economic and secure electricity supply”
- A Smart Grid uses digital technology to improve reliability, security, and efficiency (both economic and energy) of the electric system from large generation, through the delivery systems to electricity consumers and a growing number of distributed-generation and storage resources.

From a US perspective, a smart grid is not defined by what technologies it incorporates, but rather by what it can do (functionality). Therefore, US has defined the key attributes or characteristics of the 21st century grid as [22]:

- Enables active participation by consumers
- Accommodates all generation and storage options
- Enables new products, services, and markets
- Provides power quality for the digital economy
- Optimizes asset utilization and operates efficiently
- Anticipates and responds to system disturbances (self-heals)
- Operates resiliently against attack and natural disaster

In China smart grid is defined as an integration of renewable energy, new materials, advanced equipment, information technology, control technology and energy storage technology, which can realise digital management, intelligent decision making and interactive transactions of electricity generation, transmission, deployment, usage and storage [19]. Smart grid is perceived or interpreted as a strong and robust electric power system.

In the midst of a plethora of smart grid definitions, it is considered by IEEE [23] as a broad term used to include the application of secure, two-way communications and information technology to electrical power grids. This means that smart grid is the integration of power, communications, and information technologies for an improved electric power infrastructure serving loads while providing for an ongoing evolution of end-use applications. Therefore, the “smartening” of the electricity system is a revolutionary process and not a one-time event. The various definitions of smart grid account for its many sobriquets which include “intelligent grid or intelligrid”, “modern grid,” “grid of the future or future grid”, “energy internet”, “perfect power grid”, and “empowered grid”.

A distinction exists between "smart grid" and "advanced smart grid" and also between "smart grid" and "smarter grid" based on 2009 US-DOE smart grid handbook [13]. Consequently, a smart grid is defined as follows: "The smart grid is the integration of an electric grid, a communications network, software, and hardware to monitor, control, and manage the creation, distribution, storage and consumption of energy. The smart grid of the future will be distributed, it will be interactive, it will be self-healing, and it will communicate with every device." Also an advanced smart grid is defined as follows: "An advanced smart grid enables the seamless integration of utility infrastructure, with buildings, homes, electric vehicles, distributed generation, energy storage, and smart devices to increase grid reliability, energy efficiency, renewable energy use, and customer satisfaction, while reducing capital and operating costs." By the reasoning of US-DOE, "smarter grid" is achievable with today's technologies, while "smart grid" is more of a vision of what will be achievable as a myriad of technologies come on line and as multiple transformations reengineer the current grid.

However, there appears to be a consensus on the key attributes – as defined by US – of the smart grid irrespective of its diverse definitions or composition. Also there is apparent agreement that the smart grid can impact all aspects of the electric power system from generation to transmission to distribution to consumer, and can impact power delivery, communications, and marketplace.

4. Smart grid developments

Smart grid development just as the definition lacks a unified pattern. For instance, given that the smart grid concept emerged in the EU but was named in the US Energy Act 2007 [14], a difference in developmental approaches to smart grid should be expected between the EU and US. Consequently, the evolutionary drivers, motivations and path followed by each region and country towards the implementation of smart grid are unique. Reasons for this uniqueness include differences in terms of energy mix, environment, legislation, regulation, market, and customer response in each local situation. Therefore, some of the goals for modernising the grid are more important than others in some countries [3]. But the main reasons for adopting smart grid in developed countries are the reduction of losses, system performance and resource optimization, the integration of renewables, energy efficiency and a rapid-response mechanism to demand [24]. But in developing countries, there are other, new factors. For instance, the quality and reliability of electricity supply are fundamental for supporting an expanding economy, and can be achieved relatively rapidly and sustainably by designing, planning and developing a modern electricity infrastructure that is forward-looking from the outset.

In the EU, the smart grid strategy is motivated by concepts of innovation with regard to social and environmental reforms for an interactive economy [9]. Also the evolution of the smart grids in the US may be traced to several innovations in the transmission grid, such as:

- Wide-area measurement and fast controls
- Installation of power system stabilisers – phase shifting transformers, flexible ac transmission system devices
- Installation of phasor measurement units (PMUs)
- Advent of advanced control room visualisation
- Public awareness and concomitant push for more renewable energy sources in the grid

The overarching policy objective for the deployment of smart grids in the EU is to provide a more sustainable, efficient and secure electricity supply to consumers. Whereas, the principal policy objective for implementation of smart grids in the US is to provide affordable, reliable, secure and sustainable supply of electric power [21]. Furthermore, smart grid standards are not intended to be requirements or mandates in the US unlike EU. But standards are an ideal instrument to achieve a number of objectives such as:

- Seamless interoperability,
- Harmonised data models,
- Compact set of protocols,
- Communication and information exchange,

- Improved security of supply in the context of critical infrastructure,
- Robust information security, data protection and privacy adequate safety of new products and systems in the smart grid
-

However, EU and US smart grid experts share similar views on the main components and functions of the smart grid.

In the Latin America and Caribbean (LAC) regions, a very wide range of energy mix situations and market environments exist. The main unifying idea for smart grid is the urgent necessity to reduce system losses and increase the electricity system efficiency [24]. Countries of the same economic bloc have similar, if not the same, main drivers in smart grid development. While low carbon and energy efficiency are paramount for OECD (Organisation for Economic Cooperation and Development) countries, green economy growth agenda is a priority for OECD Asian countries. Also for emerging countries (e.g. BRICS) fast growth infrastructure is outstanding. The smart grid environment is extremely dynamic and changes rapidly, with emerging economies playing an increasingly important role [25]. It is further noted that non-technical losses in the power sector are small in advanced economies. For example, Japan’s electricity grid is among the most efficient and reliable in the world with average distribution losses of less than 5% (2000–2010). In contrast, the situation tends to be significantly different in developing countries. Therefore the priorities for India and Brazil are to build a grid able to carry enough capacity for the rising demand for electricity, as well as reducing the high levels of electricity losses.

Japan’s main objective is to achieve a total shift from fossil fuels to renewable energy, generating a low-carbon society [25], [26]. The US focuses on businesses and infrastructure, whereas Japan is striving to move toward a low-carbon society by developing the smart grid system [26]. Reliability improvement is much less important in Japan, where power outages at the distribution level average only about 16 minutes per year per customer, than it is in the US where such outages exceed two hours per year per customer [3]. So, Japan has developed an initial standards roadmap for the smart grid and has also formed a Smart Community Alliance, which has extended the concept of the smart grid beyond the electric system to encompass energy efficiency and intelligent management of other resources such as water, gas and transportation.

The main drivers for a smart grid in South Korea are similar to those for the US and EU – reduce greenhouse gas (GHG) emissions significantly, improve energy efficiency, and increase the share of renewable energy [25]. Both the United Kingdom (UK) and China stress the upgrade and renovation of the infrastructure of the present power system and changes to its operation but with different emphases [27]. The UK has paid most attention to the electric power distribution system, energy consumption and renewable generation, whilst China also focuses on strengthening the transmission system for their smart grid development. Therefore, comparing with the US and Europe, the Chinese smart grid appears to be more transmission-centric [28]. But in China the smart grid concept focuses on all sections of the power system, including smart power generation, transmission, deployment, usage and storage [19]. Another worthy aspect of comparison of smart grid development is the financing mechanisms. Available financing mechanisms include:

- Public funding
- Private funding
- Regulatory incentives
- External grants

Table 1 shows the available smart grid financing mechanisms for some countries and regions.

Table 1 Overview of available financing mechanisms [25]

Country/Region	Financing Mechanism
US	Public and Private funding
EU	Public funding and Regulatory incentives
South Korea	Public and Private funding
Brazil	Regulatory incentives
China	Public funding
Japan	Public funding and Regulatory incentives
India	Public funding, Regulatory incentives and External grants

In emerging countries, the cost of financing the development of smart grid technologies is for the most part borne by government finances or external grants [25]. This trend could change like South Korea's smart grids where even though the initial investment sources came from the government, the higher share of the financial burden will be borne by the private sector.

There are also diverse consumer involvements in these smart grid initiatives and the resultant varying responses from consumers. These varying responses from consumers may be related to the emphasis of their respective smart grid initiatives. For example, the emphasis is on smart metering and dynamic pricing in the US [29]. In contrast, the EU places emphasis on decentralised electricity systems in which consumers have become ‘‘prosumers’’ who both produce and consume electricity. Those ‘‘prosumers’’ can sell electricity that they generate from micro-generation technologies such as wind and solar power at household and community levels. Therefore, the EU appears to involve consumers better than the US in its smart grid developments. This could account for the most reported smart grid opposition occurring in the US, although similar trends of mistrust are emerging elsewhere such as in Korea and Australia [29]. While consumers in places such as Ontario are highly positive, negative consumer responses have been recorded in many places, in various forms and with different impacts. The result of such negative responses could include some local people blocking the development, requiring opt-out arrangements or even moratoria. Notable issues of concern to consumers include costs, health and safety, data-sharing, privacy, fairness, involuntary remote disconnection, uneven distributional effects and the impacts on vulnerable groups such as the elderly or people who are less familiar with IT.

The path to successfully turning the consumer into an active energy customer revolves around the concept of engagement [30]. A first necessary step towards consumer engagement is raising awareness and providing information about newly introduced smart technologies or mechanisms. This could be executed by means of brochures, energy consultancy services and fairs. Following the delivery of this information to customers, the next steps involve exploring ways of securing continuous consumer engagement by means of tailored tools and strategies. In order to change consumer behaviour, consumers need to be aware of their energy use, understand its impacts on the environment and on energy security, and realise the potential for energy and money savings. Generally, the amount of energy use and its impact on the system are largely abstract concepts and for most consumers, especially in the household sector, it may be difficult to link these values to daily energy-using activities.

5. Smart grid development in South Africa and lessons

South Africa Smart Grid Initiative (SASGI) was established in 2012 under South African National Energy Development Institute (SANDI). Prior to this SA's interest in smart grid could be evidenced in the development of the following standards by the Standards Bureau of South Africa (SBSA):

- Advanced Meter Reading for Large Power Users, NRS071:2004(SANS473:2006)
- Advanced Metering Infrastructure, NRS049-1:2010

The establishment of SASGI is considered as a major step towards the realisation of the smart grid opportunities in the country. The scope of work of SASGI is expected to include [31]:

- Assessment of smart grid related developments within the South African electricity supply industry
- Applicable technology consideration
- Directing standards and specifications
- Identification and motivation of enablers to promote smart grids in SA

SASGI has identified the following focus areas to ensure that technology is optimally deployed and that the grid is modernised to meet the 21st century grid requirements [32]:

- Reliability
- Security
- Economy
- Efficiency
- Environment
- Safety

Eskom has started deploying a hybrid smart grid model that supports its legacy time division multiplexing management system, while gradually introducing an Internet Protocol (IP) packet communication system, which will enable smart demand-side management, automatic correction and the connection of variable, renewable-energy generation capacity [33]. It notes that Eskom is focusing too much on the technology and not necessarily the reasons for implementing the technology. Also Eskom has implemented smart grid technologies successfully on parts of its 400 000 km of lines and has rolled out fibre-optic cables to most of its larger distribution substations, using a technique called Skywrap that winds the cables along the earth conductor of existing power lines, and has microwave and general packet radio service (GPRS) communication with its more remote distribution substations. A pertinent lesson is that the technology choices should not be made in silos, or only as pilot projects, but in a holistic fashion, aiming for a fully deployed smart grid.

While Europe presents a vital lesson to SA on perfection of strategies, policies and how to introduce behavioural changes, the US offers a typical example of smart grid technology deployment and the inherent benefits in the absence of strategy and policy perfections. SA should also avoid consumers' negative responses as witnessed in the US by ensuring active engagement of stakeholders especially consumers. A vital lesson from India is the utilisation of all financing mechanisms but one. But South Korea's approach could be adopted where though the initial investment sources came from the government, the higher share of the financial burden will be borne by the private sector. Eskom as a vertically integrated company should be the main promoter and executor of smart grid applications like Solid Grid Corporation of China – China's largest power network operating company. SA could also benefit from Japan's approach to smart grid concept especially by extending it beyond the electric system to encompass energy efficiency and intelligent management of other resources such as water, gas and transportation.

Education is vital in SA's target for sustainable electricity generation and consumption. To avoid the negative responses experienced in some places, SA needs to intensify efforts in healthy engagement with her electricity customers. One of such efforts is educating the customers on the fundamental meaning of smart grid and the accruing benefits. Also advanced countries such as the US and UK have veritable lessons for SA's tertiary education sector regarding the restructuring of Electrical Engineering curricula to reflect the required training for this 21st century and beyond the grid.

6. Conclusion

Irrespective of who receives the credit for the smart grid neologism and the diverse definitions, smart grid remains a core concept in sustainable electricity generation and consumption. Therefore, SA's strategic position in electricity generation in Africa with the attendant positive impact on the economy and environment stands undermined without smart grid. The US, EU, China, Japan and others especially BRICS members could serve as appropriate reference. Consequently, SA is presented with the opportunity to "leap-frog" and enhance the relevant proven applicable smart grid solutions. It should be noted that education in a general and broader sense is crucial in this regard. However, to allow the country to leverage the opportunities and to address the current industry challenges, effective integration and firm direction is required which SASGI is poised to address.

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Phase Envelope of Gas Condensate Systems in Nanopores

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Abstract

Natural gas from shale (NGS) and tight rocks (low permeability) is a vital fossil energy resource for this and the next decade. Significant increase in world gas consumption will be a feature of the energy sector and exploration of unconventional natural gas and oil reservoirs has been discussed at many conferences. This paper describes the complex phenomena related to the impact of adsorption (binding properties) and capillary condensation in nanopores. New two-phase saturation models and a new algorithm for search saturated gas-oil contact (GOC) in capillary condensation areas are discussed. The algorithm based on the Modified Tangent Plane Criterion for Capillary Condensation (MTPCCC) is presented. Examples of shift of phase envelopes are presented for selected composition of gas-condensate systems.

Keywords: *Unconventional natural gas, shale, gas condensate, capillary condensation, absorption, phase envelope, gas condensate, nanopores*

Acronyms

PVT	- Pressure-Volume-Temperature
VLE	- Vapour Liquid Equilibria
PR CEOS	- Peng-Robinson Cubic Equation of State
VTPR EOS	- Volume Translated Cubic Equation of State
CEOS	- Cubic Equation of State
IFT	- Interfacial Tension

Nomenclature

A,B,C	- coefficients in Peng-Robinson EOS
a,b,t	- coefficients in Peng-Robinson EOS
f	- fugacity
k	- binary interaction constant
n	- number of components
p	- pressure
T	- temperature
R	- universal gas constant
x	- mole fraction of component in liquid phase
y	- mole fraction of component in vapor phase
x	- mole fraction of component in liquid or vapor phase
v	- molar volume
w	- Pitzer's acentric factor
z	- mole fraction of component in system
Ŕ	- fugacity co-efficient
ß	- phase mole fraction

indexes

c	- critical parameter
i	- i-component,
j	- j-component
l	- liquid phase
n	- standard condition
v	- vapour phase.

1. Introduction

For a decade the importance of shale gas development (especially in the US) has increased; from 2012 it has strongly stimulate both the US and world economies (Siemek, Nagy, 2012). Natural gas production profile modelling from tight rock and shale gas reservoirs has emerged as a vital area in gas engineering. Experts insist surface interactions in the porous areas may be important in the narrow capillary radius of micropores. A complete thermodynamic analysis of the world's hydrocarbon reservoir system is impossible for many reasons (see Nagy 2002, 2003). The traditional approach to flat vapour-liquid thermodynamics may be extended to curved surfaces using gravity and adsorption/capillary condensation components, also with new nano-effects in the case of mezzo- and micropore reservoirs. These interventions, related to critical phenomena in narrow pores, will play an important role in testing vapor-liquid equilibrium in tight and shale rock..

2. State of the art of research of VLE in the porous media

Interface between phases (gas, condensate, brine) in a porous medium is not flat; capillarity and gravity segregation effects on PVT and VLE properties of reservoir fluid excluded. In classical thermodynamic analysis, which one may find in many works - Ahmed (1989), Pedersen *et al. (*1989), Firoozabadi (1999), Whitson & Brule, (2000). In the range of laboratory PVT-VLE research an additional effect of capillarity is omitted in the case of saturation phase envelopes. The pioneering Russian authors Trebin and Zadora (1968) reported a strong influence of porous media on dew point pressure and VLE of a condensate system; the observed effect was an about 10-15% increase of dew point pressure. A similar observation was recorded by Sadyk and Zade (1963) and Tindy and Raynal (1966). Other American and Canadian researchers , Smith, Yarborough (1968), Sigmund *et al. (*1973) reported no evident impact of capillarity on saturation pressure. Smith and Yarborough indicated in their paper on *wettability* the porous structure had little impact on the vapourisation process of the liquid phase in the rock. Sigmund *et al.* (1973) concluded the main reason for hypothetical impact of porous structure on the saturation pressure was a lack of fluid circulation in the cell. More interesting discussion related to impact of porous media properties on VLE was presented in a paper of Ping *et al.* (1996), Brusilovsky (1990), Firoozabadi (1999), Shapiro & Stanby (1996), Nagy (2002), Didar & Akkutlu (2013), Pang *et al.* (2012), Devegowda *et al.* (2012), Firincioglu *et al*. (2012).

Table 1:1 IUPAC classification of pores (Everett, 1972)

	Pore width	Major process
Micropore	Less than 20 Å	Monolayer adsorption and volume filling
Mesopore	Between 20 and 500 Å	Multilayer adsorption and capillary condensation
Macropore	Larger than 500 Å	Multilayer adsorption and capillary condensation

In the authors' opinions to form a continuous liquid phase demands oil *wettability*. Recent papers (e.g. .Cao Minh *et al.* (2012) confirm the existence of such type of *wettability* in non-conventional reservoirs, where up to 50% of pores are located in organic matrix (kerogen). This is also the opinion of Lee (1989), Brusilovsky (1990), Guo (1996), Firoozabadi (1999), Nagy (2002, 2003), Elamin *et al.* (2013), Didar & Akkutlu (2013), Whitson & Sunjerga (2012), Orangi (2011), Hartman *et al.* (2011), Pang *et al* (2012), Honarpour et al. (2012), Kuppe F. *et al.*, 2012. Some confirm capillary effects in deep reservoirs with low permeability and oil *wettability* should be considered. Additionally, new focus is discussed – a shift in critical parameters (Didar & Akkutlu (2013), Elamin *et al. (*2013)). The range of pore diameters in a shale gas reservoir is between 1.5-100 nm (Clarkson & Haghshenas (2012), Kang (2011), Diaz *et al.* (2009). Kang (2011), Clarkson *et al*. (2012) Diaz *et al*. (2009), Firincioglu *et al* (2012) who have all analysed the porosity and pore structure of several shale reservoir. A molecular layer density for methane at 80oC across a 3.6 nm organic slit-pore is given based on Diaz *et al*. (2009) work (see Figure 1). This was obtained by Diaz *et al*. using molecular dynamics simulation carried out in the canonical (NVT) ensemble. The estimated pore pressure for the bulk phase measurements of methane is 4,413 psi. The example of histogram of pore diameter from MICP experiment in shale is given also in Figure 2 (Clarkson & Haghshenas (2012))

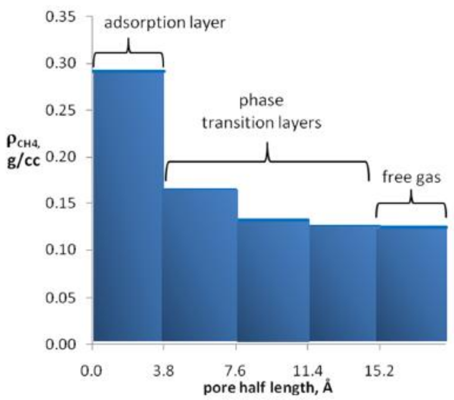

Figure 2: Molecular density of methane across the organic silt-pore (Kang, 2011 - cited from Campos *et al.* 2010)

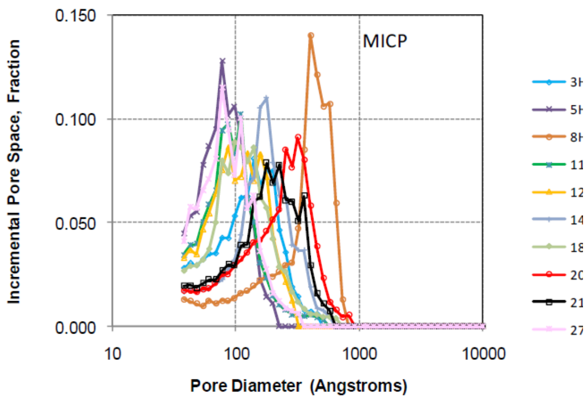

Figure 3: Nano-pore size distributions using MICP from shale after Clarkson *et al.* (2012)

2.1Hydrocarbon adsorption phenomena in porous rocks

The adsorption phenomena in the porous rock may significantly impact on the reserve distribution of tight, shale and coal-bed methane reservoirs. The adsorption process may largely distinguish from surface adsorption observed in chemical labs. The main two differentiating reasons are existence of capillary condensation phenomena in the narrow pores and a possibility of flow access blocking in the porous network. The progress in the fundamentals of adsorption theory one may find in the Dąbrowski (2001) paper. The adsorption phenomena related to the porous media are presented in many textbooks (i.e. Defay, Prigogine (1966), Adamson (1990), Dullien (1992)). Advances in the adsorption process in high pressure porous media may be found in Shapiro, Stenby (1996, 2000, 2001), Guo *et al*., (1996) and Satik, Horne, Yortsos, (1995), Kang (2011) papers.

For this paper a conservative model of adsorption has been used with a single molecular layer. The maximum thickness of adsorption film observed in the real mesopore system was 23 Ǻ (Adamson, 1990), but in this work a most conservative film of adsorption 4 Ǻ was assumed.

2.2 Capillary adsorption vapour/liquid equilibrium (VLE) model

On the curved surfaces inside porous rock (based upon Prigogine's definition) the following set of equations are valid (minus gravity force):

$$p_v(T_v,\mu_1,\mu_2,...,\mu_{nc}) - p_l(T_l,\mu_1,\mu_2,...,\mu_{nc}) = \frac{2\cdot\sigma(p_v,T_v,\mu_1,\mu_2,...,\mu_{nc})}{r_e - t} \tag{1}$$

$$T_v = T_l \tag{2}$$

Where T- temperature and μ i- chemical potential of i- component can be varied independently, r is allowed to vary at the same time; t- is the critical adsorption film. At the dew point of capillary condensation phenomena exist three types of chemical potentials:

$$\mu_i^L = \mu_i^V = \mu_i^{Vad} \text{ , i=1,..nc} \tag{3}$$

or

$$f_i^L(p_v - p_c, T, x_1, x_2, ..., x_{nc}) - f_i^V(p_v, T, x_1, x_2, ..., x_{nc}) = 0 \text{ , i=1,..nc} \tag{4}$$

$$z_i - y_i = 0 \text{ , i=1,..nc} \tag{5}$$

$$\sum_{i=1}^{nc} x_i - 1 = 0 \qquad \sum_{i=1}^{nc} y_i - 1 = 0 \tag{6}$$

The Laplace Equation (another proposal for modification of Laplace was presented by Firincinoglu *et al.* (2012), in this work only the classic equation has been used):

$$p_v - p_l - \frac{2 \cdot \sigma}{r_e - t} = 0 \tag{7}$$

Interfacial multicomponent surface tension was calculated using (8) equation:

$$\sigma^{1/E} = \frac{p_v}{Z^v RT} \sum_{i=1}^{nc} \left[\left(\frac{Z^V}{Z^L} \right) \cdot x_i - y_i \right] \cdot \pi_i \tag{8}$$

Where σ - interfacial tension (IFT), Z^v, Z^L - vapour and liquid phase compressibility factors, E- empirical dimensionless constant, π_i- parachor of i-component (Danesh, 1991, Weinaug, Katz, 1943)). This set of non-linear equations (3) may be modified by expanding using the Taylor Series and considering only the chemical potential of i-component in the liquid phase for calculation:

$$\mu_i^L(p_v - p_c(r,t), T, x_1, x_2, ..., x_{nc}) = \\ = \mu_i^L(p_v, T, x_1, x_2, ..., x_{nc}) - \frac{\partial \mu_i^L(p_v, T, x_1, x_2, ..., x_{nc})}{\partial p_v} p_c(r,t) \tag{9}$$

or using fugacity of i-component for isothermal conditions:

$$\ln f_i^L(p_L, T, x_1, x_2, ..., x_{nc}) = \\ = \ln f_i^L(p_v, T, x_1, x_2, ..., x_{nc}) - \frac{\partial \ln f_i^L(p_v, T, x_1, x_2, ..., x_{nc})}{\partial p_v} p_c(r, \mathrm{t}) \tag{10}$$

The derivative on the right-hand side is a molar partial component volume:

$$\frac{\partial \ln f_i^L(p_v, T, x_1, x_2, ..., x_{nc})}{\partial p_v} = \frac{\bar{V}_i^L}{RT} \tag{11}$$

where $\bar{V}_i^L$ is partial liquid molar volume o i-component. Equation (10) may be rewritten to the form :

$$\ln f_i^{v}(p_v,T,y_1,y_2,...,y_{nc}) = \ln f_i^{L}(p_v,T,x_1,x_2,...,x_{nc}) - \bar{V}_i^{L}\frac{p_c(r,t)}{RT} \tag{12}$$

Based upon the (12e) a derivation difference between bulk and capillary condensate dew point equations may be formulated:

$$F(N_v = 1, p_c(r,t) \neq 0) \equiv 1 - \sum_{i=1}^{nc} \frac{z_i}{K_i^{\infty}} \cdot \exp(\varepsilon_i p_c(r,t)) = 0 \tag{13}$$

Where: $\varepsilon_i = \dfrac{V_i^L}{R \cdot T}$ - component Poynting Factor, V_i^L -partial molar liquid component volume.

Based upon 12e the new capillary condensation equilibrium constant may be introduced:

$$K_i = K_i^{\infty} \cdot \exp\left(\int_0^{p_c(r,t)} \varepsilon_i dp\right) \tag{14}$$

Or, after simplification based of constant partial molar volume:

$$K_i = K_i^{\infty} \cdot \exp(\varepsilon_i p_c(r,t)) \tag{15}$$

The proposed algorithm for calculation of the capillary condensation dew pressure is found in Nagy (2002) with a new form of Rachford-Rice equation and modified tangent plane criteria for capillary condensation (MTPCCC) based upon the fundamental work of Michelsen (1982a, 1982b). Generally, the authors' use of a stability proposed test (MTPCCC) to direct computation of vapour liquid equilibrium in capillary condensation , was needed to compute the saturation pressure of flat and curved systems..

2.3The nano impact on the critical parameters of natural gas components

An interesting discussion of the phase nanopore effects was presented by Devogowda *et al.* (2012). It discussed changes in critical parameters in micro-and mesopores – as a "confinement effect." The authors discuss the Monte Carlo simulations Hamach *et al*. (2007), Sing *et al*. (2009), Travallani *et al.* (2012), Ortiz *et al*. (2005) , the numerical study by Sing et a*l*. (2009) and an experiment from Devogowda *et al.* on the construction function of critical pressure and temperature as a function of molecular weight. Devogowda *et al*. showed the possible impact of the curvature co-efficient of porous media to compressibility factor Z, phase PVT properties (without capillary effects and without adsorption). This work discussed the influence of parameters on the viscosity of the pore gas as a function of the Knudsen Number. This paper cites Sing *et al.* (2009) data for correlation of critical temperature as a function of the effective pore radius (or diameter).

$$\frac{T_{cc}}{T_c} = 0.1126 \ln\left(\mathrm{r}/\mathrm{r}_0\right) + 0.8057 \tag{16}$$

Where T_{cc}- confined critical temperature, T_c - critical temperature, r_o reference pore diameter (1.5 nm), r-actual pore diameter (nm). The critical pressure has been estimated on the basis of Sing *et al. (*2009) as a function similar to the correlation equation Antoione for vapour pressure:

$$\ln\left(\frac{p_{cc}}{p_c}\right) = 6.4265 - \frac{6.3709}{\frac{T_{cc}}{T_c}} \tag{17}$$

Where p_{cc} confined critical pressure, p_c- critical pressure. Both equations are valid only for 1.5-5 nm radius (or 3-10 nm pore diameter). A similar correlation functions for the critical pressure was also suggested by Didar & Akkutlu (2013).

3. Applying theory to reservoir gas-condensate systems

The computation procedure in n this work was carried out using a volume translated version of the Peng-Robinson Equation. From many versions of PR CEOS (Peng-Robinson, 1976, Peneloux, Rauzy, Freze, 1982, Stryjek, Vera, 1986, Jhaveri, Youngren, 1988, Patel, Teja, 1982, Stamataki, Magoulas, 2001, Lin, Duan , 2005); the Tsai and Chen (1998) VTPR EOS version was selected. Tsai/Chen VTPR EOS and VTPR in the form of being in the authors' opinions the most versatile EOS for high pressure vapour liquid equilibria; the original Tsai and Chen (1998) form of the equation was:

$$p = \frac{RT}{v+t-b} - \frac{a}{(v+t)(v+t+b)+b(v+t-b)} \tag{18}$$

Where t-the translated volume parameter, with the volume calculated by the CEOS approaches the experimental value (sees Nagy 2002, Tsai, Chen 1998).

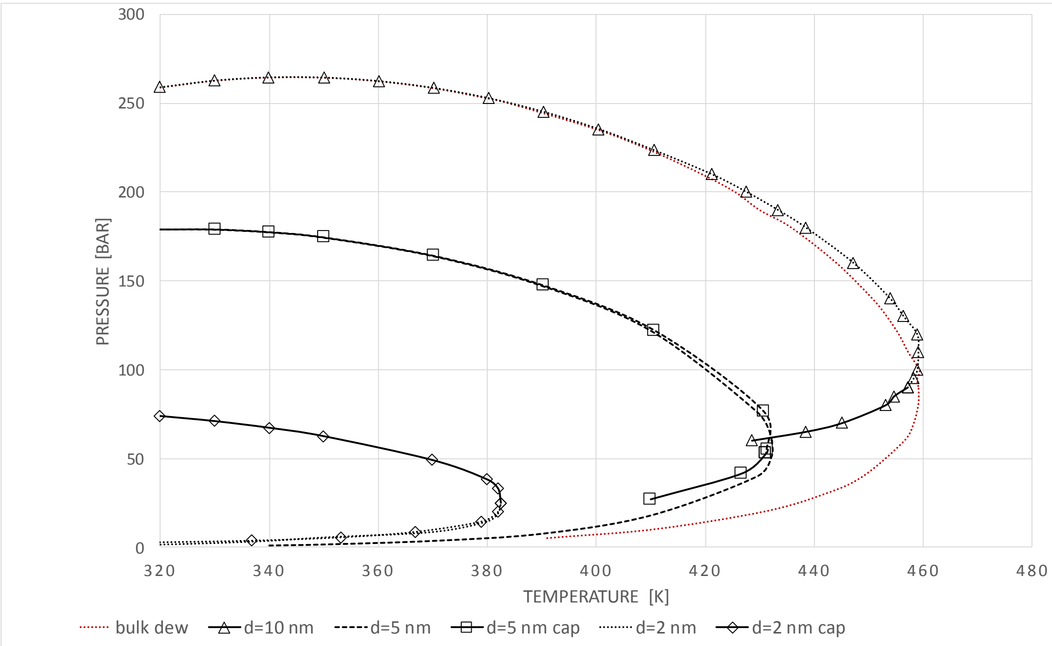

Figure 3: Phase envelope of gas condensate system (Brusilovsky, 1990) with capillary-adsorption effects and impact of confinement phenomena of critical parameters using Tsai, Chen VTPR EOS.

The most important parameter required for this algorithm was correct evaluation of surface tension of oil/condensate-gas at high pressure VLE. Presented computation is related to new papers - Fanchi (1990), Danesh *et al.* (1991); the data was used in computations. The models from Fanchi and Danesh *et al.* were related to critical parameters. The solution procedure was similar as presented by Nagy (1992) using classical critical properties taken from Reid, Prausnitz (1977) using confined parameters (eq. 16-17). The confined critical parameters were also used in this calculation in 5 and 2nm pore diameters. The mole composition of gas condensate mixture was taken from Brusilovsky (1990): methane 0.7643; ethane 0.0746; propane 0.0312; i-butane 0.0059; n-butane 0.0121; i-pentane 0.005; n-pentane 0.0059; n-hexane 0.0079; n-heptane 0.01; n-octane 0.01; n-nonane 0.01; n-decane 0.037; CO_2 0.0249; N_2 0.0012)' results are given in Figure 3. The capillary adsorption impact on the vapour phase fraction near the flat upper part dew point line was small, except near cricondentherm point – above 420K. The cricondentherm pressure was calculated with a set of equations (4-8) was located 30 bars above “flat surface” cricondentherm pressure. Main capillary effect impact was observed at the lower part of the curve, where a difference in pressure increase was close to 40 bars. The capillary effects were much smaller in the case of confined critical parameters, but still important in the lower part of the phase envelope. The confined parameters (eq. (16-17)) were used for calculation of IFT. The effect of capillarity is tiny for a pore diameter 2 nm, in case of confined critical parameters. The impact of new confined critical parameters for calculation of phase equilibria of rocks with 2, 5 10+ nm pore diameter was large, as may be observed in Figure 3. Where reservoir temperature exceeded 385K, the process of condensation of the heavy component (C_2-C_{10}) was stopped for 2 nm pore diameter. Here the saturation pressure of 5 nm pores was lower by as much as 80 bars. In that example the condensation process was expected in the pores of diameter 100-10 nm. This could be important in shale gas structures, below 3000m where the shift of average pore diameters were probable.

4. Conclusions

The porous media dew pressure of gas condensate described in this paper showed mixed impact in the case of capillary/adsorption effects. The impact of porous media in near critical condition was small. It was unlikely to expect capillarity effect in high permeability rock, but new numerical experiments may be critical in understanding of VLE phenomena; verification remains required. A shift in phase envelope in the nano-porous structure also requires investigation. Because only part of the reservoir has a pore structure diameter of 2-5 nm , the shift of phase envelope parameters must be addressed only for those elements of structure. The remainder of the reservoir, which has a pore diameter larger than 10 nm should be described using classical tools with capillary correction, as presented in this paper.

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Presenter: This paper is presented by Stanisław Nagy

An Information Security Policy Maturity Model (ISPMM)

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Abstract

With information security risk prevalent, many organisations embark on the development of an effective information security policy. And, rather than using traditional ad-hoc methods, employ security policy development lifecycles. Although these provide sound insight into the process few, if any, provide a formal assessment of development. This paper seeks to integrate security maturity assessment in the information security policy development lifecycle. Based on the integration of security engineering process areas and capability maturity levels of the System Security Engineering Capability Maturity Model (SSE-CMM), an Information Security Policy Maturity Model is proposed. The proposed ISPMM ensures a comprehensive structured methodology for measuring maturity levels of information security policy development.

Keywords: *Information security policy development, maturity model, security policy assessment.*

1. Introduction

Senior management knows best how well IT is being managed and controlled [1]. In response organisations must see to it security controls exist to ensure confidentiality, integrity and availability of information. "...Undoubtedly, the most important of such controls is an information security policy..." [2] [3]; such policy provides protection. Although security affords numerous advantages, little progress has been made in defining an approach specifically related to measuring processes or efficacy.

This paper proposes an Information Security Policy Maturity Model (ISPMM) inspired by the Security Systems Engineering Capability Maturity Model (SSE-CMM)'s Process Areas and Capability Maturity levels. SSE-CMM encompasses a framework to help measure improvement of processes development [4]. If its maturity level is assessed highly, the better (in theory) an organisation has improved process capability. In fact, the objective of this proposed ISPMM is to support organisations to improve their security level by developing a controlled security policy. In addition, the literature review discloses best practice in assessment model as vital to permit firms to structure a security policy [2].

The remainder of this paper is structured as follows: the importance of information security policy is discussed in Section 2. Then, in Section 3, the current security policy development methods found in literature is described. Section 4 covers the concept and related studies of security maturity model. In Section 5, we propose the Information Security Policy Maturity Model (ISPMM) and discuss its five phases. Finally, Section 6 offers the conclusion.

2. Information Security Policy Theoretical background

Today, companies must maintain security controls to protect valuable information. One mechanism is implementation of an effective and comprehensive information security policy. It plays a crucial role in providing guidance to employee that behaviour is in line with management rules and regulations [5].The importance of such policy cannot be understated in this field. As stated "… the cornerstone of effective

information security architecture is a well written policy statement. This is the wellspring of all other directives, standards, procedures, guidelines, and other supporting documents...” [6].
Literature confirms academics and practitioners agree such policies are the foundation for the distribution and enforcement of effective security [7] [8] [9]. “...It is well known, at least among true security professionals, that formal policy is a prerequisite of security...” [7].The issue of security is no longer a technical dimension, but, rather a people dimension [10]. Staff cause security problems no matter how carefully technical controls are implemented. Directors and management may be held liable for an employee’s conduct [6], therefore, the human factor should be considered. To enjoy acceptable security measures there is need to document policy that governs employees’ behaviour. Moreover, it should be obvious the main reason for adopting an effective security policy is to aid the top brass with concrete evidence of compliance and credibility during litigation.

Nevertheless, in spite of all this, development, implementation and adoption of an effective policy is difficult at best. Organisations make substantial efforts to ensure info security, but too often fail to accomplish goals [11]. For example, if an organisation does not conduct risk assessment before policy construction, it might lead to unnecessary expense on policies unreflective of any risk areas. Moreover, security policy assessment as an afterthought often misses serious challenges. So, how should one assess information security policy development? Is it worthwhile to assess only the end product, or also processes to reach that goal”? The writers believe policy evaluation should be considered for the entire security policy process.

Section 3 discusses various development methods available.

3. Current security policy development methods

Literature review also disclosed various available process models for the development of custom security policy. Table 1 provides a few:

Table 1: Information security policy development methods

SANS Institute [12]	**Yusufovna [13]**	**Kadam [14]**	**Mauritian Computer Emergency Response Team [15]**
1.Research policy content	1. Determine the business requirements	1.Identify the threats for business processes	1.Identify the policy development team
2.Draft policy	2. Draft the first policy called root security policy	2. Identify the vulnerabilities for business processes	2. Draft checklist-styles initially
3.Issue policy to staff	3. Indicate specific penalties for breaking the policy	3. Formulate individual policies which address each vulnerability	3. Develop detailed security policies
4.Monitor and maintain policy	4. List possible ways to request policy change and review	4. Write information security policy	4.Develop security policy from top-down versus bottom-up
5.Obtain management approval		5. Write procedures and guidelines	5.Consider all types of treats that the company faces
		6. Implement security policy at the top and operational levels	

As shown in Table 1, the authors offer basic steps for the development of a security policy document. It also reveals similarities –on which authors agree - while also showing gaps where a particular author has not mentioned any step others consider important. For example, SANS [12] does not mention action required as part of the risk assessment stage; Kadam [14] consider risk assessment as the main step to be conducted before attempting policy construction. It also becomes apparent none of the methods addresses steps related to process maturity assessment of security policy, the main objective of this paper. Only SANS [12] mentions the steps of monitoring and maintaining a security policy. Therefore, it is critical to highlight that more research is necessary in the area of security policy maturity assessment. In Section 4, different security maturity models and their main focus are discussed.

4. Security Maturity Models

A maturity model is a structured collection of elements that describes certain aspects of maturity in an organisation. This type of security model indicates the degree of development and the strength of the measures [16]. The development of a security maturity model allows an organisation to [16] [9]:

- Generate reproducible and valid measurements;
- establish actual progress in the security milieu;
- rank themselves against a range of organisations;
- determine the order in which security controls should be applied and,
- determine resources required to apply to the programme.

Literature review provides some security maturity models that firms may use to measure the maturity levels of their own processes. These are highlighted in Table 2:

Table 2: Security maturity models [9]

Security Maturity Model	Area of focus
NIST CSEAT IT Security Maturity Model	Focused toward levels of documentation.
Citigroup's Information Security Evaluation Model (CITI-ISEM)	Focused toward organizational awareness and adoption.
COBIT Maturity Model	Focused toward governance and auditing specific procedures.
System Security Engineering – Capability Maturity Model (SSE – CMM)	Focused toward security maturity assessment in software design engineering.
CERT/CSO Security Capability Assessment	Focused toward measurement of quality relative to levels of documentation.
Information Security Framework (IBM-ISF)	Focus on Gap analysis
Computer Emergency Response Team Chief Security Officer Capability Assessment	Focus on quality relative to documentation

The focus of this study is to integrate security maturity assessment models into security policy development using a maturity model approach. Therefore, the Systems Security Engineering Capability Maturity Model which focuses toward security maturity assessment is a useful tool to be used to assess and guide in this process.

4.1. Systems Security Engineering – Capability Maturity Model (SSE-CMM).

SSE-CMM is a capability maturity model (CMM) for systems security engineering (SSE). Its objectives include evolving security engineering into a mature and quantifiable discipline which enables focused investments [17]; SSE-CMM describes the stages through which processes progress as they are defined, implemented, and improved [18]. It encompasses two parts: A model for security engineering processes, project and organisational processes and an appraisal method to assess maturity. SSE-CMM is applied in three ways: First, for process improvement by achieving higher maturity levels, secondly, for capability evaluation through establishing capability levels of business partners and finally, for assurance by providing evidence of process maturity [19] [17]. It allows organisations to evaluate their security engineering practices and identify areas for improvement.

4.1.1. SSE-CMM Process Areas

The SSE-CMM consists of a number of Process Areas (PAs). These PAs are themselves divided into a number of parts called Base Practices (BPs). It specifies 129 Base Practices which are organised into 22 Process Areas. The 22 Process Areas are subdivided into 11 security engineering process areas and 11 project and organisational process areas. Each Process Area (PA) has a set of goals achieved through performing basic practices. Figure1 illustrates the relationship between the process areas, base practices, phase and capability maturity levels:

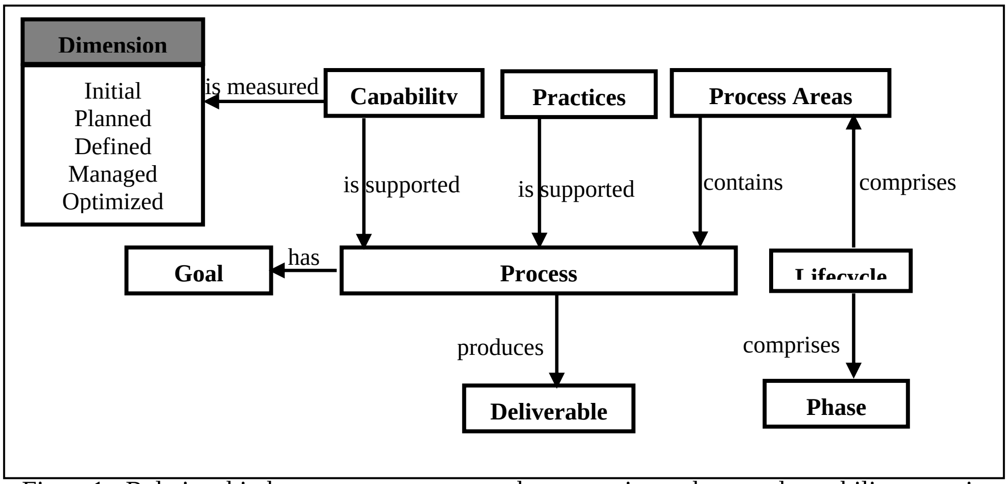

Figure1: Relationship between process areas, base practices, phase and capability maturity levels

SSE-CMM is composed of 11 PAs security engineering process areas: PA01 Administer Security Control; PA02 Assess Impact; PA03 Assess Security Risk; PA04 Assess Threat; PA05 Assess Vulnerability; PA 06Build Assurance Argument; PA07 Coordinate Security; PA08 Monitor Security Posture; PA09 Provide Security Input; PA10 Specify Security Needs; PA11 Verify and Validate Security. The 11 security engineering process areas are numbered in no particular order because the SSE-CMM does not specify a specific process or sequence of how these should be implemented. SSE-CMM also consists of the capability aspect that deals with the generic practices that are related to overall process management and institutionalisation capability [17]. This aspect is used during an assessment to determine how well an organisation performs the practices in the domain aspect. It is important to highlight that the capability maturity can be implemented in a staged or as continuous maturity models [19].

4.1.2. Staged versus Continuous Maturity Models

In a staged model, maturity is considered as a series of stages. To achieve a maturity level, firms must implement a specific PAs at a given stage [19]. Therefore, maturity is defined by the PAs at that level. The staged model provides a proven sequence of improvements, beginning with basic management practices and progressing through a predefined and proven path of successive levels, each serving as a foundation for the next [17]. Staged models give organisations a clear improvement path as it helps to easily focus and prioritise improvement effort.

In a continuous model, maturity is not so clearly defined for a specific application. PAs are used to organise the practices for the specific application as opposed to defining maturity at a specific level [19]. The continuous model allows organisations to select the order of improvement that best meet the business objectives and mitigates risk areas [18]. Maturity is defined by the nature of implementation of any of the Pas, as opposed to the implementation of a specific set of PAs [19].

In this paper it is argued as pertinent to examine capability levels with reference to specific security engineering goals. Therefore, the capability based on a staged model will be used. Undoubtedly, some institutional aspects will need to be in place before others can be effective. For example, processes cannot be effectively measured or quantitatively controlled (Level 4) until they are well defined (Level 3). Being qualified at level **n** means the current security policy has satisfied, to an acceptable rate, all security requirements of level **n** and lower levels. In other words, lower-level security requirements should be accomplished first, at least to a considerable extent, before moving to the next level. For example, the security policy construction stage can begin only after an organisation has accomplished all requirements of the risk assessment stage. In the next section different process areas requiring implementation to achieve a specific maturity level are discussed.

4.1.3. Integrating SSE-CMM Maturity Levels and Security Engineering Process Areas

Maturity levels and process areas are discussed as they are extracted directly from the Systems Security Engineering Capability Maturity Model description document [18]:

- Maturity Level 1 (informal) is characterised as *ad hoc;* no processes are defined [18]; maturity Level 2 (Planned and tracked) focuses on definition of planning solution issues. At this level, plans for performing the work are more realistically based on consideration of past performance [18] - security engineering activities (security threat analysis, security concept, security requirements and security design) necessary to define security for a system are achievable through the following process areas [17]:
  - PA02 Assess Impact: To identify impacts of concern in respect of the system and to assess the likelihood of impact occurring.
  - PA03 Assess Security Risks: The objective is to identify and assess the likelihood of the occurrence of a threat and vulnerability.
  - PA04 Assess Threat: To identify security threats, their properties and characteristics.
  - PA05 Assess Vulnerabilities: The goal is to identify and characterise system security vulnerabilities.
- Maturity Level 3 (well defined) is categorised by a defined process, documented, standardised, and integrated processes [18]. Having a well-defined process requires a communication plan strategy to ensure stakeholders are informed and provide their input to the organisation's business operation[17].PA07 Co-ordinate Security address different co-ordination aspects: between groups (intergroup co-ordination); with external groups (external co-ordination); co-ordinate security ensures all are aware of and involved in security engineering activities.
- Maturity Level 4 (managed) is categorised by process measurement [18]. Having a quantitative understanding of the process and end-results provides predictable results. PA01 Administer security control ensures security planned during design is met, thus ensuring evidence management. It also ensures solutions are verified against security requirements. This is achieved by implementing PA11 verify and validate security process area.
- Maturity Level 5 (optimising) is characterised by process control [18]. At Maturity Level 5, the organisation has a foundation which allows identification of inefficient activities to be identified and effective changes to be made in a controlled manner [19]. This is achieved by implementing PA06 build assurance argument. The main purpose of PA06 is to make sure a customer's security needs have been met.

As shown in Figure 1, System Development Life Cycle encompasses different phases as well as process areas. In this paper, it is argued different process areas that falling under the same maturity levels constitutes the phase of the proposed Information Security assess security risk phase Policy Maturity Model. For example, the Process Areas PA02 Assess Impact, PA03 Assess Security Risk, PA04 Assess Threat, and PA05 Assess Vulnerabilities constitute the. An organisation that has implemented all these requirements are considered to be at the maturity level as discussed.

5. Information Security Policy Maturity Model (ISPMM)

The proposed ISPMM is to integrate security maturity assessment in the Information Security Policy Development Lifecycle. The ISPMM is illustrated in Figure 2.When different process of each phase is accomplished, it must have an output that is documented in a specific policy document. For example, when PA09 and PA10 of phase 2 - formulate solution is achieved, a policy construction plan needs to be implemented. Figure 2 provides the proposed Information Security Policy Maturity Model inspired by the SSE-CMM Process Areas and Capability Maturity Levels.

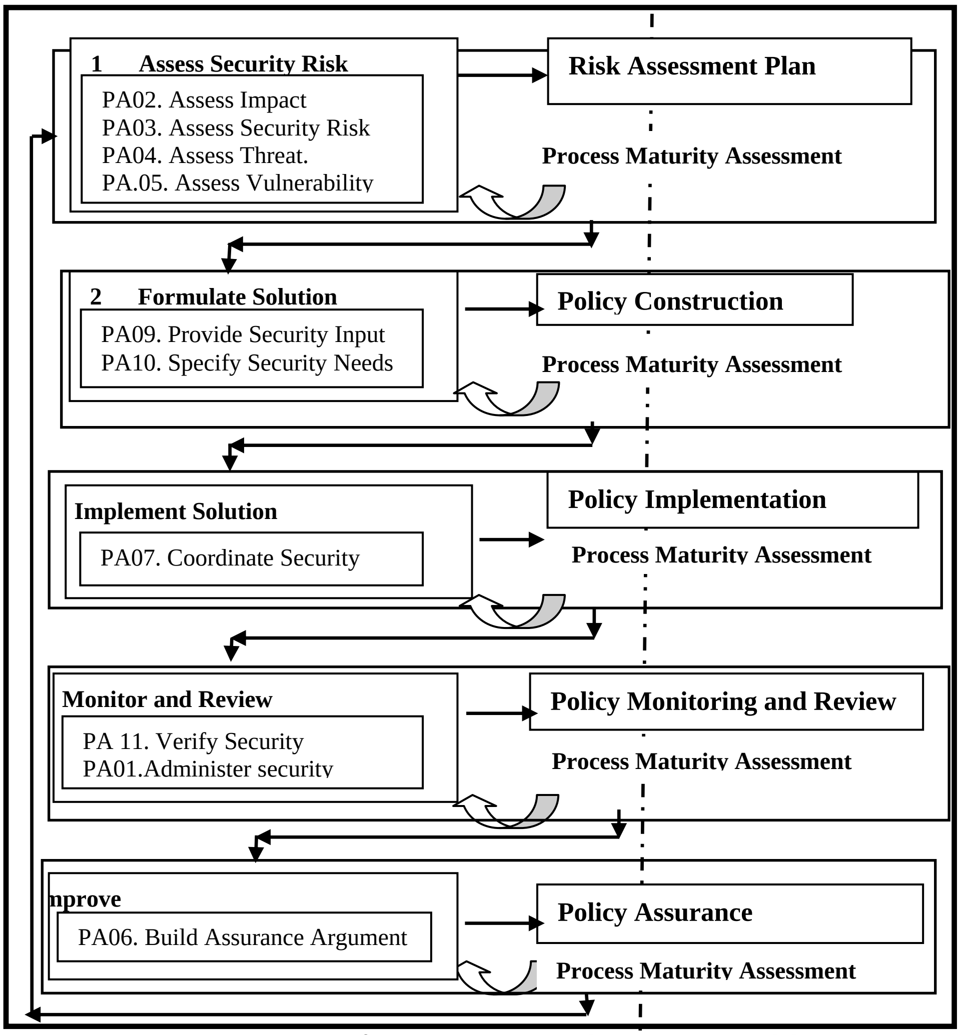

Figure 2: Information security policy maturity model (ISPMM)

The proposed ISPMM consists of five phases: **Assess Security Risk, Formulate Solution, Implement Solution, Monitor and Review and Improve.**

4.2. Phase 1: Assess Security Risk

The risk assessment phase identifies the business assets an organisation requires to protect and identifies potential threats. The four process areas (PA02 Assess Impact, PA03 Assess Security Risk, PA04 Assess Threat and PA05 Assess Vulnerability) need to be accomplished to obtain a risk assessment plan. The result will be used to decide what to incorporate in the security policies to ensure identified risks are mitigated. During this phase, a process maturity assessment is conducted to establish all security statuses. The result of the risk assessment and the process maturity evaluation constitutes the input of the next phase which is responsible for formulating the solution.

4.3. Phase 2: Formulate Solution

This phase constitutes of two process areas: PA09 Provide Security Input and PA10 Specify Security Needs. During this phase, different stakeholders should agree on security requirements required to mitigate risks identified during the assessment phase. The information gained and produced by this process area is collected, further refined, used and updated throughout a project (particularly in provide security input (PA09), to ensure customer needs are addressed [1]. Next, management must evaluate costs and benefits of implementing recommended controls to reduce risk to an acceptable level. If the envisaged expense is within budget, the next step of policy construction can begin. A one-page policy statement and high level outline of security requirements to meet the selected control objectives' requirements will be drafted. This provides a starting point to create an ideal information security policy reflecting the firm's concerns. The draft is submitted to senior staff for review and approval. If approved, a draft of a detailed policy document based on the statement is again submitted to management and if approved, the security policy is ready for publication. At this stage, the organisation is at Maturity Level 2 (planned and tracked) as plans for constructing the policy are finalised and documented.

4.4. Phase 3: Implement Solution

This phase is composed of two process areas: PA01 Administer Security Controls and PA07 Co-ordinate Security. The implementation of security policy is a process during which constructed security policies are translated into guidelines procedures and to-do lists, for use by IS users. A detailed implementation plan is then required to translate design into reality. This phase covers the following sub-steps: Define security and control requirements through detailed procedures and guidelines; allocate information security responsibilities; test security and control requirements; implement security and control requirements; offer on-going security policy training, education and awareness. At this stage, the organisation is at Maturity Level 3 (well defined) because an information security policy is in place and communicated to all stakeholders.

4.5. Phase 4: Monitor and Review

This phase encompasses process area: PA11 Verify and Validate Security. After the information security policy has been implemented, organisations should include the appropriate monitoring mechanisms to define daily activities that ensure the security policy is enforced .The following activities should be executed: Produce measurable results reflecting users' behaviour; perform system audits and reviews; perform intrusion detection and penetration testing; perform user activity audit trail analysis and audit policy compliance. All this ensures security policy requirements implemented are verified and validated in respect of requirements. Therefore, the organisation is at Maturity Level 4 (managed).

4.6. Phase 5: Improve

This phase encompasses one process area - PA06 Build Assurance Argument. For an organisation to be at Maturity Level 5 (optimising), the requirements of the implemented security policy must satisfy a client's operational security needs; following on, the lifecycle needs to repeat from Phase1, Assess Security Risk. There are numerous unknowns during the last phase and organisations will likely identify a new threat not considered, a new regulation requirement now needed, or a business capability forgotten requiring catering for in policies.

5. Conclusions

Today, information systems security evaluation research focuses on assessment of how information systems are secured in relation to some sort of policy statement. Little research has targeted specifically the process assessment of security policy development lifecycle. The writers suggest the assessment of the policy itself has no merit without an evaluation of the security policy development process. Based on the security engineering process areas and capability maturity levels of the System Security Engineering Capability Maturity Model (SSE-CMM), an Information Security Policy Maturity Model (ISPMM) is proposed. ISPMM presents an integrated, holistic approach to ensure incremental process maturity of security posture and performance of development. It provides an evolutionary path from an *ad hoc* information security policy development approach to a more structured, defined, manageable and repeatable quality approach which protects critical information, yet allows milestones to be created, measured and met in a projected manner.

The model proposed can definitively enhance the maturity of information security if it is implemented in an educational organisation. Once a policy is implemented all the stakeholders , from management staff, lecturer to, students need to be trained on requirements as discussed in Phase 3 of the proposed model; later, there is need for security policy compliance mechanisms. For example, before a user accesses the Internet, a pop-up message requires a user to abide by terms and conditions of access security. The Internet access policy requirements could, for example, prohibit downloading of movies or music or, access to websites that might jeopardise security.

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Design and Implementation of a Packet Loss Estimator for a Campus Area Network

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Abstract

This study implemented a packet loss estimator for a campus area network using a passive approach on a slow speed network. The proposed technique was represented with pseudo codes and Unified Modelling Language (UML) activity diagrams. Program codes for the estimation was written in C++ and developed in an application programming interface using the concept of expired flows. A benchmark implementation was set up using a test bed in a controlled environment before the proposed technique was deployed on the case study network. The proposed technique was compared with active Ping using Relative Error and t-Test. The results revealed a considerably smaller average relative error value of 0.009 for the proposed technique and 0.2 for Ping. Furthermore, result calculated from the t-Test conducted on the measured values showed that the difference between the means for the two tests were different. These results showed that the proposed technique measured more accurately than Ping.

Keywords: *Passive monitoring, Packet loss estimation, Campus area network, Port mirroring.*

1. Introduction

The heavy reliance and dependence on computer networks in diverse fields for accomplishing day-to-day activities have propelled the need for proper management and efficient monitoring of the network for optimum functionality. The Importance of Campus Area Networks in today's world cannot be overemphasized as its impact/relevance cuts across administrative, academic and non-academic activities, organizational, educational, information and resources sharing. In developing countries like Nigeria, observation shows that users of campus area networks experience dissatisfaction and though resources of huge cost are been invested in to the network, users satisfaction is still very minimal. Over the years, computer networks have been monitored using different metrics depending on a particular characteristic. Some of the metrics usually used include latency (delay), path bandwidth, path reliability, link utilization, throughput, load and packet loss ratio.

Packet loss ratio has been identified as one of the most important metrics for identifying poor network conditions and estimating packet loss on these networks have been challenging since the frequently-used active monitoring approaches using probe packets cannot truly capture the packet loss experienced by the real traffic on the network. Apart from network overhead incurred which additionally compete with real user traffic, there is also scarce data on packetloss estimation on campus area networks and so data is not available for timely planning strategies, network analysis, decision making and documentation for future use by network engineers and researchers.

In this paper, a packet loss estimator was designed and implemented on OAUnet (a case study of a campus area network) with an archiving system for historic data on network performance. In contrast to several other related work, the estimator was adapted to run on a slow speed network obvious on most campus area networks in Nigeria. Some causes of packet loss on the case study network were also discovered and control measures suggested for implementation.

The rest of the paper is organized as follows. Section 2 describes the existing related work while Section 3 outlines the proposed technique and its integration within a Campus Area Network. Section 4 presents experimental evaluation results and discussion and finally, Section 5 concludes the paper.

2. Existing Related Works

Packet loss ratio is one of the most important metrics for identifying poor network conditions and packet loss occurs when correctly transmitted packets from a source never arrive at the intended destination as stated in Papadogiannakis et al.[1], Ciuffoletti and Polychronakis [2] and Surya and Manjunath [3]. Packets are usually lost due to congestion and/or corruption. Other causes which eventually result into congestion or corruption of packets include signal degradation due to multipath fading, faulty networking hardware, faulty network drivers and normal routing routines [4] and [5]. Effects of packet loss are evident in connection quality, data transfer throughput and performance degradation like jitter [5]. The understanding of the dynamics of packet loss behaviour is of particular importance since it could have significant impact on the performance of both TCP and UDP applications. Packet loss estimation can be broadly categorized into two approaches and they are based on passive and active network monitoring. Over the years, most of the literatures have largely been geared towards active monitoring. Active monitoring involves the injection of a certain number of packets into the network for measuring how many of them are lost. Examples of this include Sting [6], Badabing [7], Zing [8] and Ping [9].

Ping uses the ICMP protocol to send probe packets to a target host [10] at fixed intervals, and reports loss when the response packets are not received within a specified time period. However, ICMP packets are often rate limited or blocked by routers and firewalls. Another active tool is zing, which estimates the end-to-end packet loss in one direction between two cooperative end hosts, by sending UDP packets at Poisson modulated intervals with a fixed mean rate. Badabing also measures the one-way packet loss by sending fixed-size packets at specific intervals. Sting is an active monitoring tool that measures the loss rate in both forward and reverse directions from a single host to any TCP-based server, by exploiting TCP's loss recovery algorithms. All active monitoring tools incur an unavoidable network overhead due to the injected probe packets, which compete with the real user traffic. Generally speaking, an active measurement approach is problematic because of the discrete sampling nature of the probe process [7]. Passive measurement systems in contrast can only record the time at which a packet was actually present on the network, at the point that the passive measurement system is connected. This makes passive methods timely and reliable and many different aspects of the network like traffic, behaviour and timing can be studied efficiently this way. Besides active tools, there also exist methods or tools that use passive network monitoring for measuring packet loss, based on the TCP retransmission mechanism [11]. (i.e TCP's loss recovery algorithms). However, there are several applications, such as tftp, which use UDP instead of TCP. Techniques for estimating the loss rate based on the TCP protocol were also presented in Allman et al. [12]. However, emphasis was placed on individual clients and they could not be used by other external applications, e.g., for improving routing or selecting a replicated server with the best network conditions. Benko and Veres [11] proposed a TCP packet loss measurement approach based on monitoring sequence numbers in TCP packets. They described a method for estimating packet loss by passively monitoring TCP sessions at an independent measurement point on the network. Their algorithm estimates packet loss rates by observing inconsistencies in the sequence number progression seen in TCP packets belonging to a particular flow. However, they did not evaluate the convergence speed of their algorithm.

3. The Proposed Technique

The proposed packet loss estimation technique was based on the passive approach. It was described for a real-time packet loss measurement for a campus area network. The technique was adopted from the works of Papadogiannakis et al. [1] and Friedl et al. [13]. The proposed model differs in that it was adapted to work on a slow speed network unlike previous works that were meant for high speed networks.

Furthermore, specialized interface cards were deployed specifically on previous works due to the high speed nature of the network. For high speed networks, Hardware monitoring adapters such as DAG and SCAMPI were used and were not dependent on the system clock of host computer. These adapters used high quality clocks with external pulse per second (PPS) signal synchronization so that the absolute time accuracy was about 1 microsecond. Ethernet NICs are commonly available for 10Mb/s, 100Mb/s, and 1Gb/s, allowing host based capture via libpcap and tcpdump or related software. When a packet is received on an interface, it generally interrupts the host machine. In the interrupt handler the packet is retrieved, and a time-stamp is added to it from the system clock. The packet is then queued to be passed to the network stack for processing, which will make it available. Ethernet is widely deployed within campus networks and LANs, making it easily accessible by researchers. Often a site's external network connection runs over a single Ethernet link at some point, making it a desirable point for network measurement. A conceptual frame work was derived for this work. The conceptual view of the proposed passive estimation technique was described using the analogy displayed in Figure 1. Network traffic on a VLAN of a particular subnet (INTECU subnet) was directed towards a specified interface (eth0). The traffic was examined and classified into flows from which the proposed technique acted on and carried out the estimation. The result was stored in a database and the output displayed on an interface.

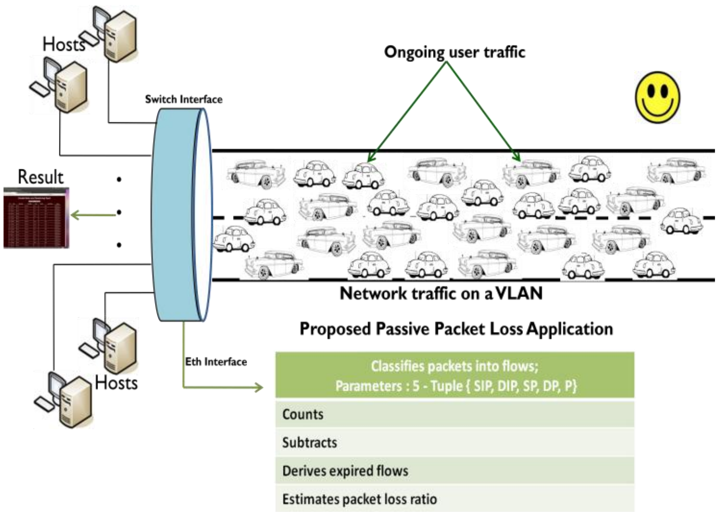

Figure 1. Analogy describing the conceptual view of the proposed passive packet loss estimation technique.

The framework combined the hardware, software, processes, functions, data and output flow together. The configuration of the experiment started at the edge of the network - the access layer from which connection was made to the case study network. The switch belonging to a subnet (INTECU) being a managed switch, was configured to allow for port mirroring. Network traffic on this switch was directed to an interface - eth0. Network traffic that flowed through the interface were been examined and classified accordingly to meet defined specification within a time frame from which statistics were gathered and estimation was carried out. These activities were all programmed into functions, processes and applications within the proposed passive packet loss estimation technique which ran as a daemon. Raw data were generated and transferred into logs that could be viewed as html or stored in a database from which an interface was built to allow results generated, to be available at the front end for easy accessibility and viewing. Figure 2 displays the conceptual framework of the technique.

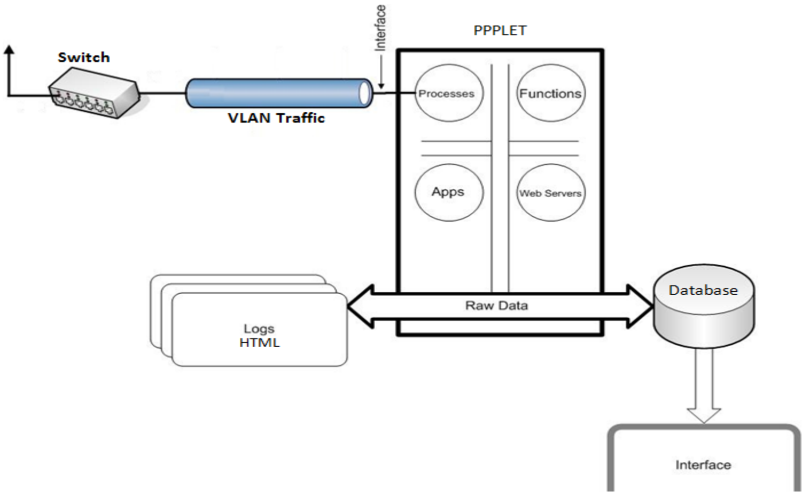

Figure 2. Proposed Passive Packet loss Estimator Conceptual Framework

3.1. Pseudo Code

After the variables have been defined accordingly, counter and loss parameters were initialized. At the interface, flows were created using the flow descriptor - source and destination IP addresses, source and destination port number and the protocol used. When a flow was successfully created, a flow identifier 1 was returned, else flow not created was returned with any other integer value and flow becomes closed. The packets within successfully created flows were then observed and examined. If these packets were received within a specified time frame and are in right order, then the counter "K" for packets received was incremented. Packets not received as at due time were regarded and considered as expired. The counter "J" was incremented accordingly. This gave the number of lost packets. The total number of packets sent was thus calculated by adding counted received packets and counted lost packets. From the statistics gathered, the packet loss ratio was estimated and transferred as output. The pseudo code is as displayed:

```
Variables, fd, fdloss, time, k, j
Initialize counter  fd, fdloss, k, j

      CREATE flow m
             If (m ==1)
                    "flow created successfully";
             Else
                    "flow not created";
             End
      While m == 1
             If packet received within time t
                    k++
             Elseif packet not received within time t
                    j++
      Elseifm != 1
      CLOSE flow m
             End
      Endwhile
      OUTPUT Result: k = counted received packets
                  j = counted lost packets
             k + j = Total packets sent
```

3.2. UML Activity Diagram

The activity diagram of the proposed passive estimation technique is displayed in Figure 3. This shows the flow of execution of the proposed technique. The packets received for a particular flow are counted within a specified time and regarded as received flows while others are regarded as expired flows. An expired flow is a flow with no arriving packets for a specified timeout. The application adds the counted received packets and the expired packets to get the total number of packets actually sent. The number of packets received is then subtracted from the number of packets that were sent to get total number of lost packets. The packet loss ratio is thus calculated and transferred as the output.

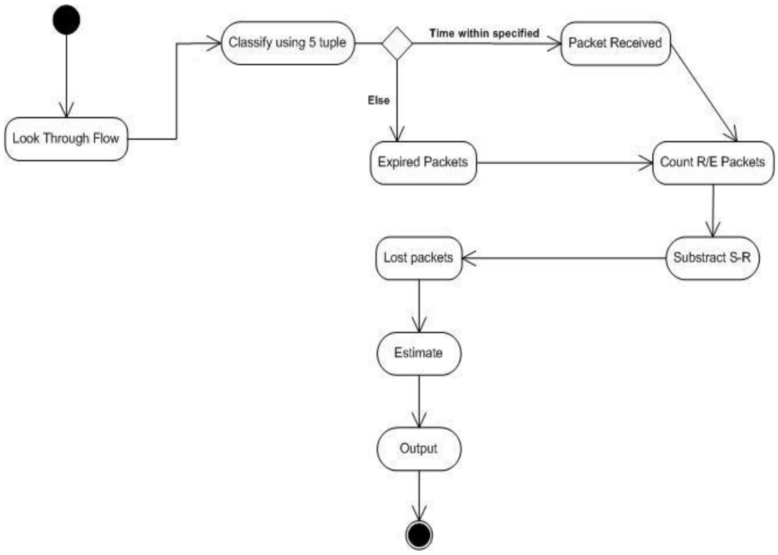

Figure 3. UML activity diagram of proposed passive estimation technique

3.3. Implementation Process

The test bed environment for this project work was carried out on a Linux platform, specifically on a Debian distribution called Ubuntu. Three desktop PCs were used in this experiment. All three were HP-PC compatible computers with Intel Pentium Dual-core, running the 32-bit Ubuntu Desktop Edition, version 10.10 operating system. The HP-PC compatible computers were chosen as they were readily available for use. The system configuration for the three desktop PCs used were:

- Processor: Intel(R) Pentium(R) Dual CPU E2160 @ 1.80GHz, 1.80GHz
- Installed Memory (RAM) : 1.00 GB
- System Type: 32-Bit Operating System.
- NICs : Ethernet
- Hard disk size : 80GB , SATA

Two of the PCs depicted a “source” and a “destination”. The traffic between the two PCs was forwarded through the third PC “gateway” that introduced artificial packet loss at controlled rates using NetEm. Other tools configured on these systems included traffic generators and the proposed passive packet loss estimation technique.

NetEm was configured on this machine as it served as the central point for all packets to pass along. Packet loss was implemented in NetEm by randomly dropping a certain percentage of the packets before they were queued. All these three PCs had installed and configured on them, Ubuntu operating system and the passive monitoring software – Mapi [14]. Various packet loss rates ranging from 0% to 100% were introduced to all the traffic generated at varying intervals. Each run lasted for specified minutes ranging between 5mins and 60mins. This was compiled and documented in a table which was used to generate a graph. Figure 4 shows the setup of the test-bed and the individual configuration settings carried out on each computer system.

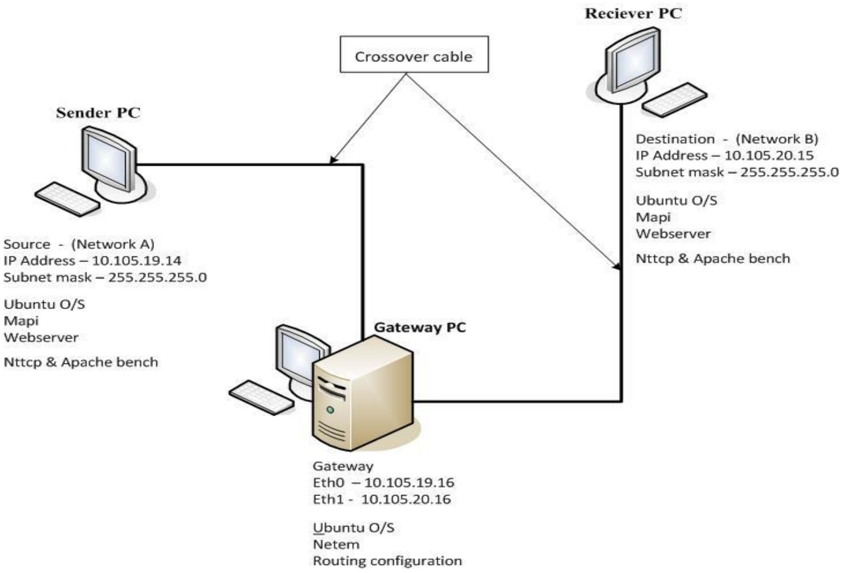

Figure 4. Setup of test bed and individual configuration settings displayed.

Estimates of packet loss can be inferred by observing relevant statistics gathered from the network of study. The command C:\>netstat -s -p tcp was typed on the command prompt to validate this. Filezilla was used in this project work to perform uploads and downloads from which statistics were derived in analyzing the netstat output.

3.4. Configuration of Networking Equipment

A portion of the network was configured for the real experiment to be deployed. The switch that connected the Vlan to the router was configured using baud rate 4800 to allow for port mirroring. The HP Procurve Switch 4000m J4121A model was used. The technique was tested on the access layer of the OAUnet. Figure 5 gives a visual description of the network configuration showing the “backbone” switch connected via a 100 Mbps speed link upstream. Results generated were compiled and documented accordingly. Results generated were stored in a database created by MySQL and an interface was designed to display results using PHP. Lampp software was used for this implementation.

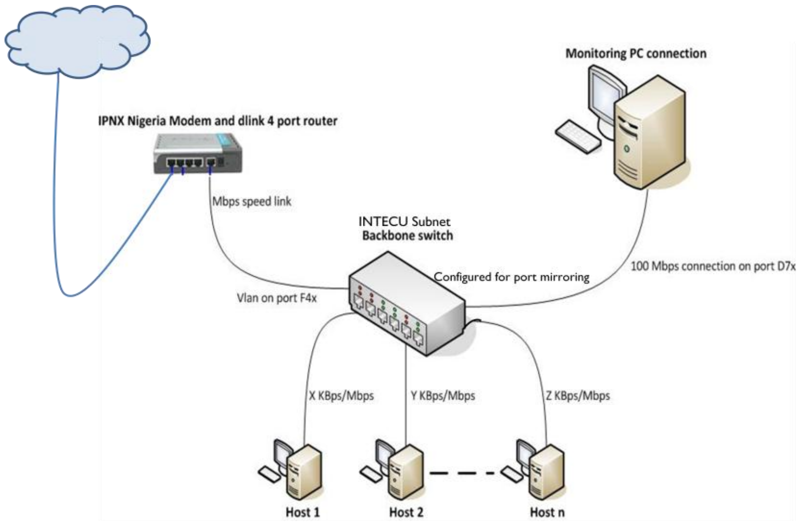

Figure 5. Visual description of the network configuration.

4. Results and Discussion

The "Sender" host generated traffic destined to the "Receiver" host. The traffic of both hosts was actively and passively monitored and results taken are as displayed. Each run lasted for 60 mins. Table 1 presents the results for loss range between 0 and 100%. The measurement error is defined as:

error = | introduced loss - measured loss | which gives the absolute error value.

Table 1. Relative Error and t-Test for Ping and PPPLET by NetEm introduced loss.

	Ping Result			**PPPLET Result**			Difference in Measurement Errors	
A(%)	B_1(%)	C_1(%)	D_1(%)	B_2(%)	C_2(%)	D_2(%)	|PPPLET - Ping|	T-values
0	0.00	0.00	0.00	0.00	0.00	0.000	0.00	0.00000000
5	3.00	2.00	0.67	5.00	0.00	0.000	2.00	5.00000002*
7	9.00	2.00	0.22	6.80	0.20	0.029	1.80	-4.38359224*
8	12.00	4.00	0.33	8.45	0.45	0.053	3.55	-3.00119095
9	14.00	5.00	0.36	9.09	0.09	0.009	4.91	-0.00000001'
10	8.00	2.00	0.25	10.00	0.00	0.000	2.00	5.00000001*
12	9.00	3.00	0.33	11.75	0.25	0.021	2.75	4.59018365*
15	12.00	3.00	0.25	14.82	0.18	0.012	2.82	2.79876332'
20	17.00	3.00	0.18	19.93	0.07	0.003	2.93	8.82390158*
25	22.00	3.00	0.14	25.00	0.00	0.000	3.00	2.59807621'
30	30.00	0.00	0.00	30.00	0.00	0.000	0.00	0.00000000
35	33.00	2.00	0.06	34.94	0.06	0.001	1.94	6.80723385*
40	36.00	4.00	0.11	40.00	0.00	0.000	4.00	6.92820323*
45	47.00	2.00	0.04	45.00	0.00	0.000	2.00	-3.46410161
50	54.00	4.00	0.07	49.50	0.50	0.010	3.50	2.99755402
70	66.00	4.00	0.06	70.10	0.10	0.001	3.90	5.35000000*
100	100.00	0.00	0.00	100.00	0.00	0.000	0.00	0.00000000

A% - NetEm Introduced loss
B% - Estimated / measured loss
C% - Absolute measurement error
D - Relative error

4.1. Performance Evaluation

The performance evaluation was carried out using relative error and t-test. The comparative accuracy of these measurements was determined by looking at their relative errors.

Relative error = $E_{rel} = \frac{|x-x^*|}{x}$

Where : x = measured value (Estimated), x* = actual value (benchmark)

In order words, relative error = absolute error / actual value of measurement and
Average Relative Error = summation of relative errors / total number of runs.
The results revealed an average relative error of 0.009 for PPPLET and 0.2 for Ping. A t–Test was also conducted on the values to compare and assess whether the means of the two tests were statistically different from each other. It is a measure of the variability or dispersion of the figures or values.

The formula is given as: $\frac{\sum ai - \sum bi}{\sqrt{n}(S_1^2 + S_2^1)^{\frac{1}{2}}}$ where $S_i^2 = \frac{\sum a_i^2 - n\left(\frac{\sum ai}{n}\right)^2}{n-1}$ = variability test,
ai or bi = result of test-runs for each loss point, n = total no. of runs for the loss point.

The risk level (called the alpha level) was set at 0.05 and 0.10. Also, the degree of freedom (df) was determined as: the sample size (n) minus 1 = 2. The t-values were looked up in a standard table of significance. The calculated t–values were compared with the tabulated t-value of (-4.30, +4.30) for a two-tailed test at alpha levels, α = 0.05 and 0.10 at 2 degree of freedom. From the calculated t-values in Table 4.1, it was concluded that apart from the 3 points where the calculated t-values were the same (0.00000000), at α = .05, 8 other points (with *) have calculated t-values larger than the tabulated t- value (-4.30, +4.30) which showed significance. At α = 0.10, the tabulated t-value was 2.92. At this level, most of the calculated t-values were significant except for only 3 points (with '). Points having less calculated t-values were due to the wide variation in the Ping results as compared to the PPPLET. Hence, the significant points were within the acceptance limit of the null hypothesis of `no difference` in the PPPLET and Ping results.

A graph of NetEm vs Ping and Proposed passive packet loss estimation technique was plotted. This is displayed in figure 6. From the graph, a close line of fit existed between the NetEm introduced loss results and the proposed passive packet loss estimation results. Unlike the ping results that displayed a wider deviation from the NetEm introduced loss. Sometimes the ping overshot in its measurement and sometimes the measurement were far below what was experienced. It should be noted that these results were cumulative averages of several runs of the techniques.

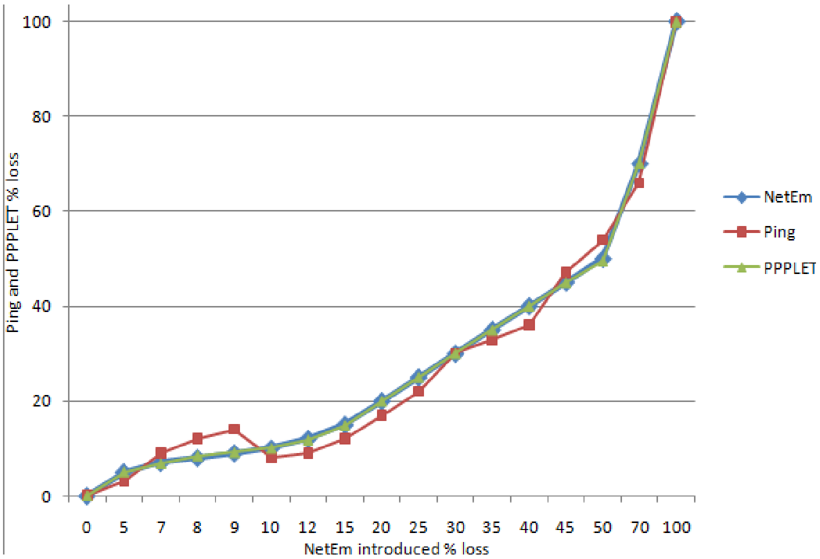

Figure 6. Graph of NetEm vs Ping and PPPLET

5. Conclusion

In this paper, we have designed and implemented a more reliable packet loss estimator using open-source system for a campus area network. Packet loss information serves as a good measure of QoS in campus networks. From the results, our proposed scheme PPPLET has presented lower relative errors in estimating the artificially introduced packet loss rate in the network and found to measure more accurately than Ping.

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Presenter: The paper is presented by Abiodun Oyadeyi

The Efficacy of Engineering, Design and Technology Projects

A Real Time ETL Framework for Railway Freight Systems

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Abstract

The world has encountered major cultural revolutions - Stone Age, Iron Age, Agricultural Age, Industrial Age - the Information Age. Today's impact dictates how businesses should be run while avoiding the pitfalls of being trapped in a bygone era's style. Presently, data is the most important resource behind organisational success or failure. The methods employed to collect, represent and store data determines quality and usefulness of information to organisations for making timely, strategic decisions on business direction, customer focus and tactical issues to survive a competitive environment. Business intelligence tools, such as data warehousing, offers a capability for extracting, transforming, loading, storing and visualisation of information from an organisation's integrated heterogeneous source systems in strategic format. Data should be on hand when required, with latency between capture and availability reduced. Railway systems account for many freight transactions, but lack of integration poses threat of a strategic decision gap. This paper seeks to determine the effectiveness of using data warehousing in railway freight systems to assist management in strategic decision; Zimbabwean Railways is the example .

Keywords: *Business Intelligence, data warehousing, extraction, transformation, loading, visualisation*

1. Introduction

Railways transformed the transport industry [1]. From humble beginnings in the 18th Century, when the railway was nothing more than a light horse- or ox-drawn wagon on rails, it evolved through steam locomotives, to a bulk passenger transporter in the 1830s and the invention of the diesel and eventually electric locomotive of today, capable of speeds in excess of 400km/h while hauling tons of freight [2]. Colonisation and the discovery of minerals in Africa accelerated railway system development in Africa, evidenced by Cecil John Rhodes to create an unbroken line from the Cape to Cairo. In [3], it is noted, “the lines that eventually became Rhodesia Railways were also part of Rhodes’ plan to extend British hegemony from the Cape of Good Hope To Cairo.”

1.1. Railway System Operations

Any railway transport system is considered as bulky, but cheaper to run as distance increases [4]. Most railways companies are national entities; few are operated privately. Core business is freight; transportation of passengers is often considered a community social responsibility.

A railway company’s main assets are locomotives and wagons. Wagons can be coupled drawn by one or more locomotives to pull them - becoming a train. Railway companies own a network of tracks; their trains travel thousands of kilometres. Since railway lines can be extensive, to enable freight loading and offloading at intermediate destinations stations are established along the route. Sidings are small sections of line branching from main lines to service industries [3].

1.2. National Railways of Zimbabwe Origins

The National Railways of Zimbabwe is a parastatal company. Its core business is transportation of freight and passengers, achieved through its customer services units, passenger services units, goods and reservations offices to be found at key access points. Dev elopement was directed by mining and agriculture, and to link the land-locked country with ports in Mozambique, South Africa, and neighbouring Zambia [5].

Line construction began from Fontesvilla (55km from Beira) to Mutare in September, 1892 and from Vryburg in Cape Province to Bulawayo in May, 1893. The link-up between Harare and Bulawayo took place in October, 1902 with materials supplied via the Beira line. The next stage was a line northward. This began in 1903 and eventually reached the Zaire border in December, 1909. Until 1927 the system was operated by Mashonaland Railways Company under the title Beira/ Mashonaland and Rhodesian Railways; from October 1, 1927 the Rhodesia Railways Company was established. From October 1, 193 Rhodesia Railways Ltd assumed ownership of the entire Zimbabwe-Zambia system. On June 1, 1979 Rhodesia Railways became Zimbabwe Rhodesia Railways and finally National Railways of Zimbabwe (NRZ) after independence on May1, 1980 [5].

1.3. Zimbabwean Freight System and data processing technologies

For hardware technology NRZ uses three Fujitsu Siemens Itanium servers, each with 16GB RAM, 1.60GHz and HDD – 2x300GB. The first is the database server where the Wagon Tracking Database is hosted, a second is a web server which hosts the middle tier of the Wagon Tracking Application System (web services), and a third is a payroll database server. The NRZ also owns a Redundant Array of Inexpensive Disks (Raid) – a pool of storage devices interconnected to provide large capacity for backup of applications and database data; it has thousands of desktop PCs in use.

The Wagon Tracking and Freight Rating system is the software application used by the NRZ for recording freight transactions on the railway network. The application was developed using VB.Net 2003 and interfaces to an Oracle 10G Database. The main functionality of the system is to record new wagons and locomotives, build trains, send and report trains upon arrival, goods rating and viewing reports. Other systems include a payroll system, a passenger reservations system and other support installations.

1.4. Data obtained from the Freight System

Data obtained is accessed through directly querying tables. It provides comprehensive data in relational tabular format only for addressing tactical needs, but also provides structured data easily transformed, exported and used for different requirements. Today’s database provides information on stations - the administrative locations where most freight management activities are delivered. The database also stores information on commodities being transported - for example maize, copper, iron ore, oil, cars etc; wagon and locomotive details are a major item on the database. Freight transactional information and customer information is also maintained as are sister railway administrations - Botswana Railways, Zambia Railways and Transnet (South Africa). Information on locomotive types - diesel, electric, steam and different models are also stored. It maintains information on train classes - ballast, liner, passenger, freight. Other information includes wagon types, regional information - southern, eastern and northern details, plus system user details.

1.5. Data unobtainable on the freight system

What is missing is that databases fail to provide strategic information required to answer strategic questions about vision, customer focus, future operations and company direction, required to provide management with policy answers on business direction.
These are examples of strategic questions unobtainable at the click of a button:

1. Seasonal freight demand in all regions.
2. Which are main customers and why is NRZ preferred?
3. Tonnage trends in, say the last five years and for, say, the next 15?
4. Optimum routes required fro optimum profitably?

5. Empty wagon (gross inactive tonnage) distances travelled by wagons empty and loaded?
6. What strategies might improve image to retain customer loyalty and attract new business?

1.6. Strategic Information Problems

Most railways run several transactional applications to account for day-to-day freight transactions. These are often on heterogeneous platforms, not integrated, leaving a decision support gap. Technologies used by NRZ are adequate only for data storage, recording transactions and accessing data. For information visualisation, trend analysis, pattern recognition and dashboards, such technologies prove insufficient and unable to support strategic decision making. From the questions that cannot be answered it is deduced the present system is inadequate. Such answers require a level of modelling and analysis - thus new methods and technologies are required to bridge the gaps and help maintain profitability and sustainability.

2. Business Intelligence Technologies for strategic information

Several technologies for gaining strategic information are found under the business intelligence (BI) concept. Successful freight rail companies identify customers' emerging needs and act decisively. BI refers to all techniques that might be implemented to simplify information storage, integration, processing, discovery and analysis, making it possible for all decision-makers to easily access, understand, analyse, collaborate, and act on information anytime, anywhere. BI helps manage, and improve the performance of individuals, processes, teams, and companies and assists managers address core strategic questions such as: What happened? What is happening? Why did it happen? What will happen? What do we want to happen? [6].

Business Intelligence encompasses the following technologies;

- Data Mining – (DM)
- Decision Support Systems - (DSS)
- Data Visualisation - (DV)
- Data Warehousing – (DW)

Data Mining (DM)-According to [6], "...Data mining is the analysis of data to discover previously unknown relationships which provide useful information..." "...Data mining is the entire process of applying computer-based methodology, including new techniques for knowledge discovery, from data..." [7].

Decision Support Systems (DSS) - According to [8], in handbook for decision support systems, "...A decision support system is a computer-based system that processes knowledge in ways that allow decision making to be more productive, agile, innovative and/or reputable..." Decision support systems are management level computer information systems combing data, sophisticated analytical models and data analysis tools to support non-routine, unstructured, and unique decisions in a rapidly changing and unpredictable business environment [6]. A DSS is an integrated, interactive computerised system/subsystem that gathers, stores, processes and presents data from a wide range of sources, typically for supporting creation of meaningful business decisions.

Data Visualisation (DV) – Is the process of using analytics, reports, dashboards, cubes and dices to gain a deeper insight on data for strategic decision making.

Data Warehouse (DW) - A data warehouse is a central repository for all or significant parts of the data collected by an enterprise's business systems. The term was coined in [9]. IBM commonly uses the term "information warehouse." According to [9], "…A data warehouse is a subject-oriented, integrated, time-variant and non-volatile collection of data in support of management's decision making process…" It is subject-oriented making it possible to analyse a particular subject area - for example, sales. It integrates data from multiple heterogeneous legacy system data sources and is a time variant since it enables historical data to be stored. In [10], it is noted that, "…A data warehouse is a copy of transactional data specifically structured for query and analysis…" - a functional view of a data warehouse.

The data warehouse helps transform source systems data into strategic material, which is then used to address strategic questions. It also helps separate analytic environment from the OLTP environment to avoid running complex queries on OLTP databases, so slowing the performance of the mission-critical freight management databases. Data warehouse technology was successfully implemented by the Chinese Railways for its freight data and Indian Railways for passenger reservations [11] [12].

Data warehouse objective is to have data integrated into accurate information. The writers found the data warehouse the best solution as it co-ordinates all resources and integrates data from legacy systems to assist in addressing the strategic questions. A data warehouse supports business strategy and information dashboards, monitoring business goals' progress with instant, up-to-date information from disparate sources. Business organisations have three levels of information generating systems - transaction or routine or production processes e.g. order taking; tactical processes e.g. production planning and strategic processes e.g. business and market planning [13]. All are integrated into a single version - hence the proposal to develop the data warehouse for NRZ.

3. How can BI become relevant to NRZ?

BI, through the implementation of a data warehouse helps integrate data from heterogeneous legacy systems into a single version of the truth, paramount to strategic decision making. A data warehouse also brings:

- Ann ability to store extensive data;
- to provide ETL, a data visualisation capability, to answer strategic and intelligent questions;
- availability of diverse powerful software for data warehouse development;
- ability to integrate data across functions or systems to provide a complete picture of information needs;
- ability to avoid interference with a fast performing transaction system by running complex queries and reports during business hours;
- ability to reorganise data to support fast reporting and analytic querying and application of modelling tools, trending, and information visualisation not supported by ordinary databases and,
- cleans up data to give data consistency data integrity.

3.1. Data warehousing to solve the NRZ strategic information problem

From analysis the writers propose development of a BI prototype DW solution for the NRZ based on selected strategic questions to determine if a fully-fledged data warehouse will provide al solution to strategic decision woes. The proposed solution will benefit freight management, making strategic decisions capable of taking management to new competitive horizons.

Figure 1 indicates the high level architecture of the solution to be developed.

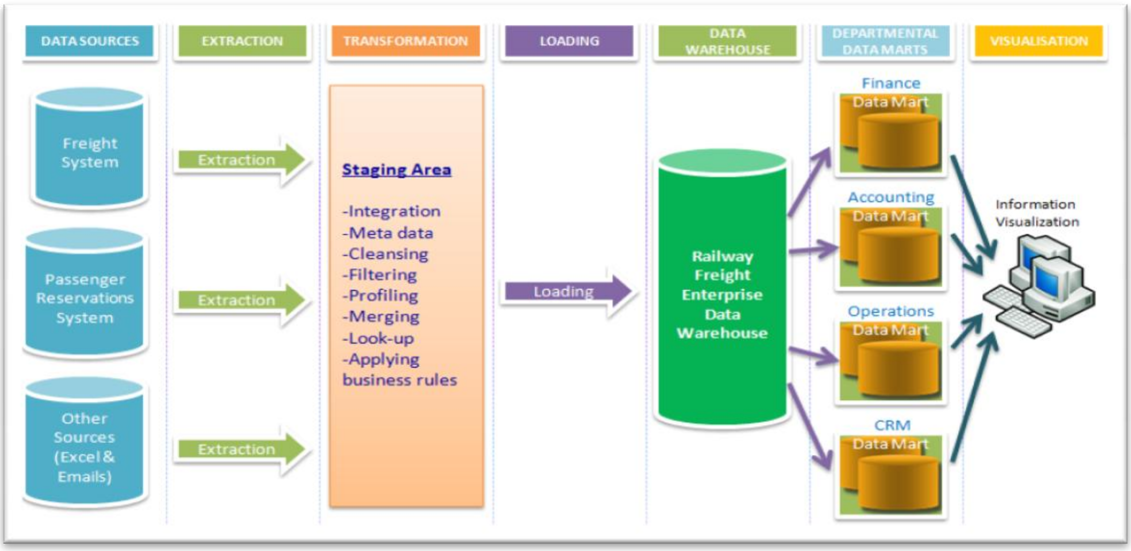

Figure 1: Left to right, architecture of proposed DW solution for the NRZ

Figure 1 represents the architecture of the proposed solution for the NRZ freight prototype DW. The top-down approach was selected and emphasises development of the enterprise data warehouse (EDW) before the data marts. This helps create a single integrated data repository for all heterogeneous source systems, promotes effective central management of data and provides a central data resource pool for decision making.

3.2. ER-Diagram of source data

Figure 2 shows the ER-Diagram of the NRZ Wagon Tracking and Freight Rating System, source system for the prototype NRZ/DW solution. This system is a comprehensive and detailed OLTP system with many tables.

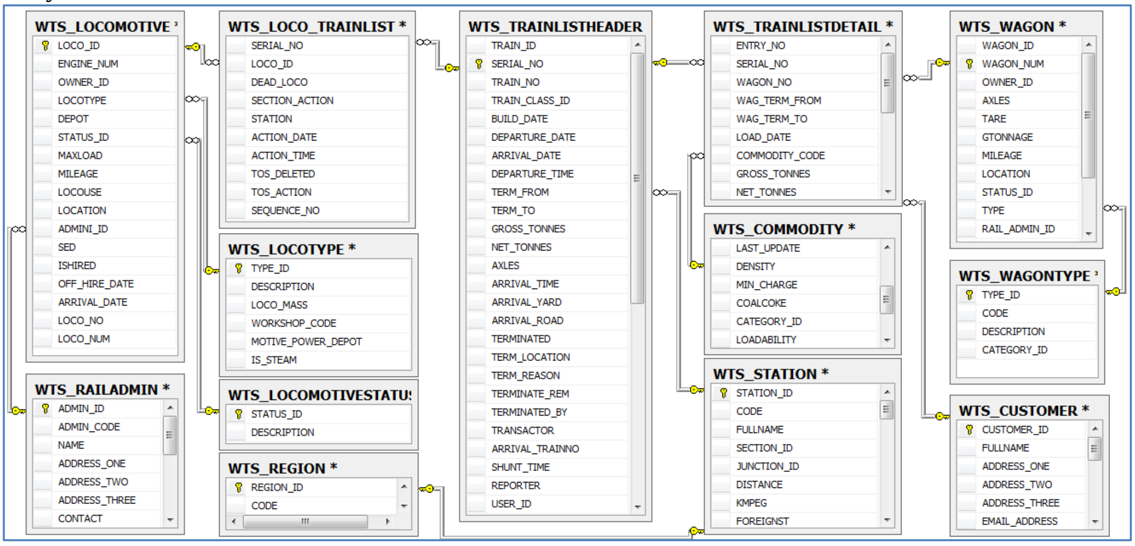

Figure 2: ER diagram for the NRZ freight system – source data

3.3. Proposed Methodology

Main tasks involved in the development of a prototype DW Solution for NRZ:

- Step 1 – Determine the questions on which to base the DW solution.
- Step 2 – Dimensional Modelling based on questions in Step1.
- Step 3 – Develop a prototype of a real-time ETL package addressing strategic questions.

3.3.1. Step 1 – Determine strategic questions for a DW Solution.

The DW solution is based on the following selected strategic questions:

1. **What is the station by station demand in freight product-wise by region?**
   This question was chosen to try to determine patterns in freight demand by station - to discover which stations generated the largest freight demand product-wise. This served to identify products usually ferried to each station, then plan and prepare for such demand trends observed. From this question the stations' dimension is derived as:
2. **Who are our main customers, from which regions and what can be done to retain them?**
   This question helps identify main customers by volume/frequency of freight movement and also products ferried. The question is important as it details customers, needs, locations and freight demand patterns. This creates an ability to serve such customers better and maintains successful win-win business partnerships. From this question the customers' dimensions are derived as:
3. **Which types of locomotives haul commodities by region and why they are preferred?**
   This is a vital strategic question providing introspection into business history of performance. The answer helps understand which locomotives are mainly used for hauling which commodities. From this question the locomotives' dimension is derived as:
4. **What is the empty wagon gross/inactive tonnage; distance ratio travelled by empty wagons/loaded?**
   This seeks to establish whether wagons travel greater distances loaded or empty. When wagons travels further empty it is an indicator of poor planning; they should be harnessed to ferry another load going to *that* destination, or closer. From this question the wagons' dimension is derived as:

3.3.2. Step 2 – Dimensional Modelling via strategic questions.

Dimensional modelling is a logical design technique to structure business dimensions and metrics being analysed along these dimensions. It helps to capture measures critical to business users. A dimensional model includes fact tables and lookup tables; fact tables contain measures of interest. Lookup tables provide detailed information about attributes [14]. **A fact table** is the central table containing the calculated metrics; it has foreign keys for dimensions to help link them into a star schematic. The dimensions and the fact table are shown linked:

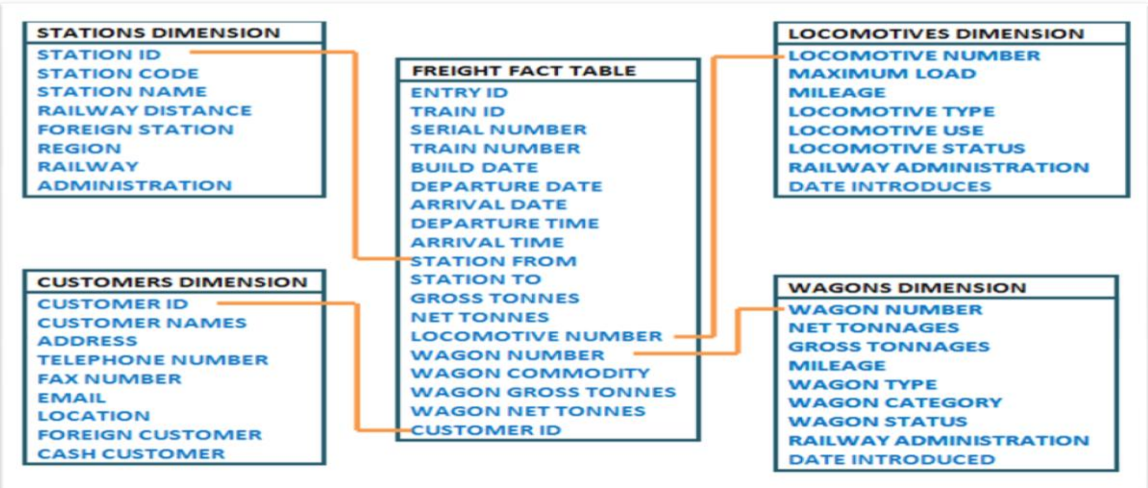

Figure 3: ER diagram for the NRZ freight prototype DW solution

3.3.3. Step 3 – Developing real-time ETL package for prototype DW

The ETL is analogous to the car engine when it comes to the DW. It is small and concealed as is a car engine, but drives a big body and provides similar perks - visual BI reports, dashboards, cubes and other analytic tools for strategic decision making. An ETL is the powerhouse of the DW and responsible for the extraction, transformation and loading of transformed data into the DW.
Extraction Process is the process of extracting source data from legacy systems for the DW. A DW is an integrated collection of data to support management decision making. The integrated data arrives from various sources; the process of gathering named extraction [13].
Transformation process is data extracted from disparate legacy systems needing to be transformed into a standard format compatible with the DW. The transformation process involves splitting, merging, conversion, calculation, looking-up, and formatting [13].
Loading Process is the process of getting the data into the DW when transformation is completed.

3.3.4. ETL Design for proposed DW solution - real-time ETL packages

The ETL was implemented using packages developed in SQL Server Business Intelligence Development Studio (BIDS) [15]. Each dimension and fact table has a package responsible for loading data. The dimensions are grouped into one composite package to simplify design and implementation. Figure 4 demonstrates:

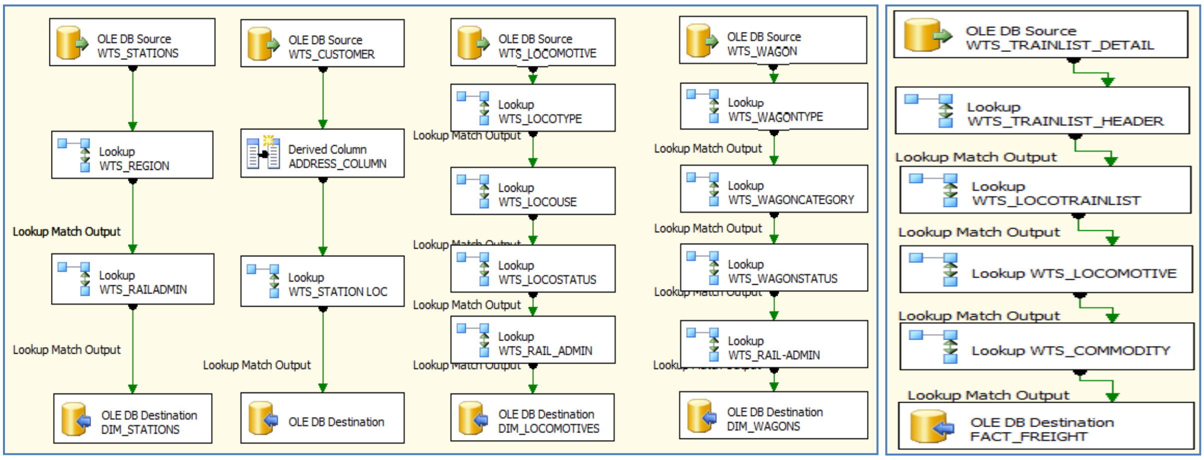

Figure 4: Package design view for load dimensions and load facts packages

3.3.5. Loading Process

This is the process of loading data into the prototype DW. The process is on-going as data is continuously fed from the OLTP source systems [16]. The loading process is on a daily basis as the OLTP system to the DW. The loading process is carried out by the ETL packages. As packages are handled, the white boxes (in Figure 4) represent the tasks not yet executed; yellow, tasks in progress, but not yet completed. The green boxes represent completed tasks in Figure 5:

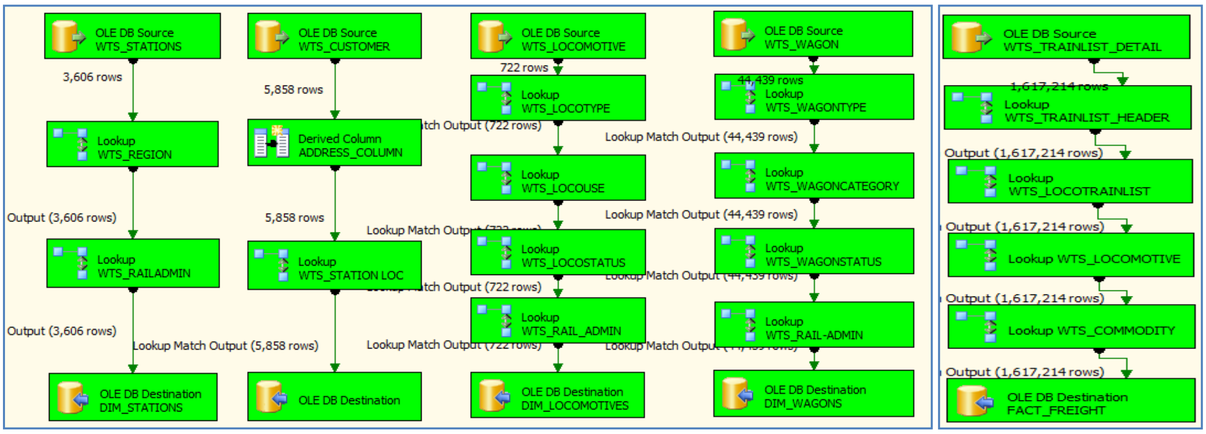

Figure 5: Loading process completion for the Load Dimensions and Load Facts packages

All the tasks/boxes in the package are shown as green, indicating the package has successfully finished execution. Statistics indicate a total of 3 606 rows extracted, transformed and loaded into the stations' dimension; 5 858 rows into the customers' dimension; 722 rows into the locomotives' dimension and 44 678 rows into the wagons' dimension. The entire loading process takes place in fewer than 30ses, highlighting the speed and efficiency of DW solutions in handling large data volume.

4. ANALYSIS AND INTERPRETATION OF RESULTS

This section provides an analysis and interpretation of the paper's findings and compares them with what an ordinary transaction processing system could have produced with the use of simple queries.

4.1. Local research results

The dimensions contain meaningful data optimised for decision making. The information in the dimensions is easier to understand and visualise, queries are easier to write for retrieving information, reducing complex joins and queries' execution time. The information can be combined with information from other dimensions through the fact table, to afford a global view of NRZ's organisational position. The fact table provides the measures needed for decision making and cubes, reports and dashboards are easily created for strategic decision making.

4.2. Actual research results

The research was guided by four selected strategic questions, all precisely addressed with the use of cubes and BI reports. Two questions have been selected to demonstrate actual results:

1. Which locomotives are mostly used for carrying which commodities by region and why?

This strategic question is addressed by a cube which provides the information relating to the ferrying locomotive types used for different regions (some are not electrified). Net and gross tonnages by each locomotive type and the regions are shown:

.

	REGION									
	Eastern		Foreign		Midlands		Southern		Grand Total	
LOCO TYPE	GROSS TONNES	NET TONNES	GROSS TONNES	NET TONNES	GROSS TONNES	NET TONNES	GROSS TONNES	NET TONNES	GROSS TONNES	NET TONNES
14TH (GARRETT)	5038	184	255211	149806	333012	129057	13836	4108	607097	283155
15A (GARRETT)	40866	13563	1406094	499068	65437	5418	527761	282403	2040158	800452
16TH (GARRETT)	182795	114584	24481103	11571568	112195	55595	16232774	9639267	41008867	21381014
20TH (GARRETT)			170192	99603	29589	17157	708507	321065	908288	437825
B.D.1			8211278	4427630			6668925	2768873	14880203	7196503
B.D.2			947374	443444			849191	358120	1796565	801564
D.E.10A (DIESEL)	116856327	56794741	311809436	169273279	343010744	155588652	526943309	308096394	1298619816	689753066
D.E.11A (DIESEL)	35477104	12601206	12977470	7124378	988408255	894027991	50867887	28391068	1087730716	942144643
D.E.2 (DIESEL)	5493	276	252820	113706			328818	111652	587131	225634
D.E.3 (DIESEL)	15802	4979					294888	190442	310690	195421
D.E.6 (DIESEL)	5880730	2205091	3555362	1784846	3505568	1443256	15150447	5248751	28092107	10681944
D.E.9A (DIESEL)	15957253	5597549	4706656	2359648	62110581	27692867	58011252	50894782	140785742	86544846
E.L.1 (ELECTRIC)	20573941	9293437	556727	331883	58444506	37046389	290358	137517	79865532	46809226
GT36	15470	7599	4989068	2706266	302591	156428	12895119	7553835	18202248	10424128
U20C			3689913	2028784	1683170	1020466	7731014	4341498	13104097	7390748
Grand Total	195010819	86633209	378008704	202913909	1458005648	1117183276	697514086	418339775	2728539257	1825070169

Figure 6: Cube example, net and gross freight tonnages by locomotive and by region

The cube helps visualises the information on locomotive performance in three dimensions i.e. locomotive type, region and tonnage moved by locomotives of a particular type. For example, the DE10A (Diesel) locomotives moved freight gross tonnage of 689 753 066 for all regions; gross tonnages moved in the southern region for all locomotives was 697 514 086. The overall grand totals of freight moved by all locomotive types and in all regions is shown in the bottom right corner of the cube as; Gross: 2 728 539 257; net: 1 825 070 169 tons.

2. What is the empty wagon gross tonnage/ratio of distance travelled by empty/loaded wagons?
Figure 7 indicates the cube generated from the prototype DW solution to address the fourth strategic question. It shows largest distances are covered when wagons are loaded – effective use of fleet.

	REGION				
	Eastern	Foreign	Midlands	Southern	Grand Total
LOADING STATUS	DISTANCE	DISTANCE	DISTANCE	DISTANCE	DISTANCE
EMPTY	50807491	65867052	126147828	109648293	352470664
LOADED	57164787	187161319	260217172	247284180	751827458
Grand Total	107972278	253028371	386365000	356932473	1104298122

Figure 7: Cube example empty/loaded wagon/kilometer/ratios

This cube visualises information in three dimensions - loading status, region and distance. It indicates total distance covered by empty wagons for the eastern region as: 50 807 491km; loaded wagons travelled 57 164 787km; a favourable situation and economic sense. The total distances covered by wagons for all regions were: Empty: 352 470 664km; loaded: 751 827 458km; total distance covered by all wagons, 1 104 298 122km.

4.3. Global research results

The NRZ prototype DW solution has also indicated several advantages which include - meaningful reporting services for visualising information, providing a central repository of the organisation's heterogeneous source systems, data extraction, transformation/loading, which free transaction processing systems from the burden of complex queries which slows operational performance. It improved decision making leading to better service, and strategically positioning the NRZ in the face of competition; the DW solution hence might be applied to all African railways.

4.3. Results discussion

While data used for the research study was limited in scope compared to the capacity a full fledged DW would be able to handle, however, results proved promising, motivating the researchers to implement the technology with large data sets. Research was to determine the viability of DW solutions in railway freight systems with a view to improving strategic decision making. The researchers conclude with a 90% confidence level DW technology as effective for railway freight systems. The integration of data from disparate systems ,which is analysed, cleansed and transformed, loaded into a DW, then further refined by OLAP and MOLAP, helps to create multi-dimensional cubes and dashboards [9]. The cubes help understand information more clearly, making it easy for management to make effective strategic decisions at the click of a button.

4.4. Research contributions

This research contributed by:
Adding to existing knowledge and literature implementation of DW solutions to improve decision making in railway systems, with the NRZ as a case study.

- Being an eye-opener to most railway organizations, as most administrations are unaware of DW technology and its benefits potential.
- Helping railways and sister organisations in the freight business to consider a DW solution to address strategic informational needs and taking business to new horizons.
- Helping raise strong awareness to researchers, businesses, schools and stakeholders of the critical and strategic role DW solutions provide.

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Design and Development of an Infrared Heater for Plastic Waste Gasification

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Abstract

This paper outlines the design, manufacture and analysis of a far infrared ceramic heater for plastic gasification purposes. The study includes the theoretical overview of the mathematical modelling of the far infrared ceramic heater as well as the mathematical modelling of the gasifier and the thermal system enclosure. The study gives an overview of manufacturing process of the ceramic infrared heaters along with the testing of the manufactured heaters in order to check the validity of the heaters and their influence in transforming the plastics from one phase to another. Characterization of the heat source and the spectral properties of the different plasticshave been performed, heat up and cool down of the ceramic infrared heaters have also been discussed using LabVIEW software. Gasification of plastic waste as carbonaceous material, basic reactions during the gasification of plastics, gasification products has also been discussed along with the gasifier properties. Using infrared module voltage as an input, model predictions of temperature and wavelengths using Fourier equations were found to agree well with experimental data. The ceramic infrared heaters developed in this research are fully functional and all test results obtained are accurate to a very fair degree. The results obtained from the gasification experiment shows that using infrared heaters on gasification is practically sound because of significant advantages of infrared heating compared to the landfill and incineration. The work is intended to develop a low-cost ceramic infrared heater solution to be used in plastic waste gasification.

Keywords: Gasification, Infrared heater, Plastic waste, LabVIEW.

1. Introduction

With modern lifestyles, the consumption of plastics continues to increase every year and therefore the amount of plastic waste has also increased. Traditional ways of plastic waste disposal have been either to bury or burn them in landfill incinerators, respectively. Landfills and incinerations however are associated with serious environmental concerns. There are different technologies such as gasification and pyrolysis which transform waste plastic to useful fuels or petrochemicals. One of these technologies is infrared radiation heating which is often said to be more efficient and cost effective. The use of infrared radiant heating in the gasification of waste plastic is performed because infrared radiation does not emit harmful fumes and do not require air movement [1]. This paper is concerned with the use of infrared energy in the disposal of plastic waste.

2. Background review

Waste plastics are one of the most promising resources for fuel production because of useful gases that it contains. Plastic recycling can be divided into three methods; mechanical recycling, chemical recycling and energy recovery. Chemical recycling which, converts plastic materials into useful chemicals have been recognized as an advanced technology process [2]. In recent years the gasification of plastics has been intensively conducted and some useful results have been seen in different studies [3], [4].

Gasification is a process that converts carbonaceous materials such as plastic, coal and petroleum into carbon monoxide and hydrogen. The gas yield from the gasification process is called syngas. Equation 1 and 2 represent the raw material decomposition and reaction with oxygen during gasification.

$$\mathrm{C_x + H_y \rightarrow xC + \frac{y}{2}H_2} \qquad (1)$$

$$\mathrm{C + \frac{1}{2}O_2 \rightarrow CO} \qquad (2)$$

A two-stage thermal gasification process for plastics has been developed by Tashiro [5], [6]. Polyethylene (PE), polypropylene (PP) and polystyrene (PS) have been gasified using two stage thermal degradation. Plastics have been transformed to liquid andthen to gas during gasification. A gasification process which converted waste plastics to synthetic gases (CO, H_2), at a high temperatures (over 1600K) has also been studied by Takatoshi [7].

3. Methodology

3.1 Overview of methodology

The plastic samples were washed with hot water prior the gasification tests to remove dirt and any possible contaminants on the surface of the samples. Samples were also weighed using measuring scale to measure the mass of each sample before and after gasification. Samples of High density polyethylene (HDPE) and Low density polyethylene (LDPE) from municipal solid waste were collected and cut into $5cm \times 5cm$ squares.

The methodology used within this study;

- Mathematical modeling of an infrared ceramic heater and infrared gasifier.
- .Wavelength measurements of waste plastics using Fourier Transform Infrared Spectroscopy (FTIR).
- . The design of a data acquisition system to verify results.

3.2 Modelling and design

The design of a ceramic infrared heater which has a surface temperature lower than 800℃ shall be considered. The heater is made of a ceramic body with resistance wire (filament) embedded in it. Afibre blanket placed behind the filament to avoid heat lossfrom the back of the heater. Ceramic infrared heaters are designed to emit wavelengths in the far infrared range at certain operational temperatures. As voltage is applied,a current and resistive loss in the filament that translates to heat build-up. The higher the temperature the higher the filament resistivity, with a reduction in the amount of current and power consumed. The rise in filament temperature results in heat transfer by means of conduction to the ceramic body and then radiation to the environment. The passage of electric current through the filament when voltage is applied is given by

$$i(t) = \frac{U}{R}(1 - e^{k_1}) + c_2 e^{k_2} k_{1,2} = -\frac{1}{2RC}\left[1 \pm \sqrt{1 - \frac{4CR^2}{L}}\right] \qquad (3)$$

Where c_2 is a constant, $i(t)$ is the current flow at time$t$, $k_1 = {}^{R}/_{L}$, $k_2 = {}^{-1}/_{RC} + {}^{R}/_{L}$ and U is the energy storage.

The rate at which energy is transferred from the heater surface to the surface of the target is given as:

$$E_{out} - E_{in} = 0 \qquad (4)$$

Energy outflow due to net radiation leaving the surface is given by:

$$E_{out} = \varepsilon\sigma(\pi DL)(T^4 - T_{sur}^4) \qquad (5)$$

The change of energy storage due to the temperature change is:

$$E_{st} = \frac{dU}{dt} = \rho c V \frac{dT}{dt} \qquad (6)$$

3.3Testing and measurements

Testing of the manufactured heaters has been conducted by connecting the panels to the 220 volts ac mains supply with a temperature sensor been mounted to the front of the heater to sense heater surface temperature. The maximum temperature values recorded for each panel were 187.8℃and 234.9℃ respectively. Figures 1 and 2 shows the measured heating curves of the manufactured heaters and table 1 shows the temperatures and calculated wavelengths for each heater panel.

Table 1: Manufactured heater specifications

Parameter	Heater 1	Heater 2
Size (mm)	265×198	216×122
Typical operating temperature (℃)	187.8	234.9
Wavelength (μm)	6.2	5.70

The wavelength of the manufactured heaters is calculated using Wien's displacementlaw. The wavelength of the emitter is inversely proportional to the temperature, and is given by;

$$\lambda = \frac{b}{T} = \frac{2.8977685 \times 10^{-3}}{℃ + 273.15} \qquad (7)$$

Where b is a constant.

Transmittance measurements of LDPE and HDPE using FTIR spectroscopy were conducted and the results are shown in figures 3 and 4. A sample wavelength measurement was implemented to determine the infrared absorption wavelength of LDPE and HDPE. Peak absorption values shown in table 2were calculated using formula 8.

$$\lambda_A \mu m = \frac{10000}{\lambda_T cm^{-1}} \qquad (8)$$

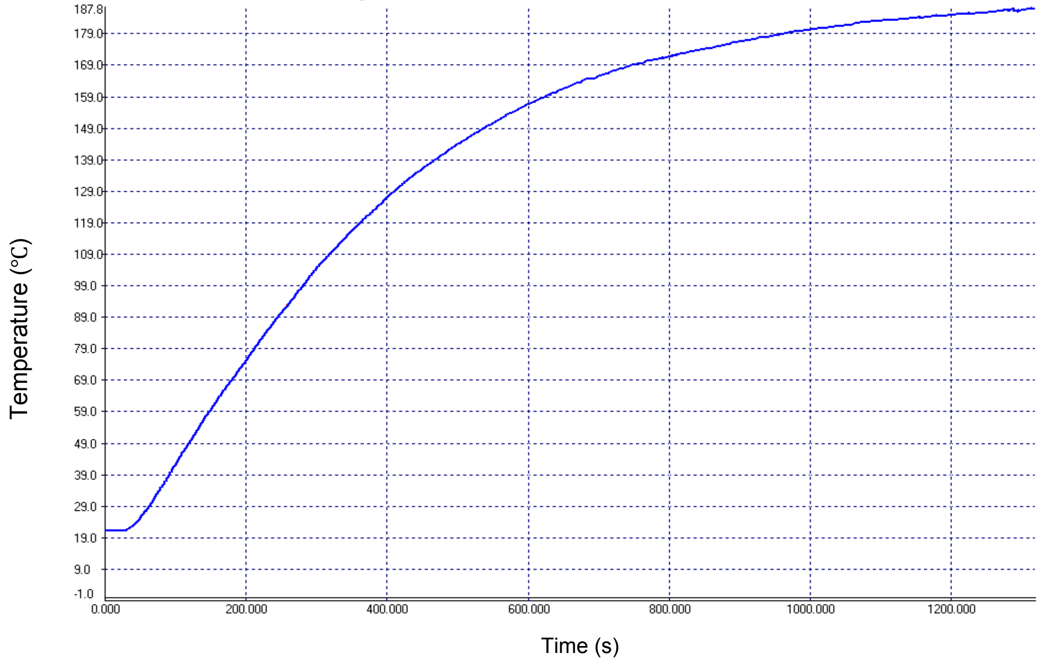

Figure 1: Heating rate of heater 1

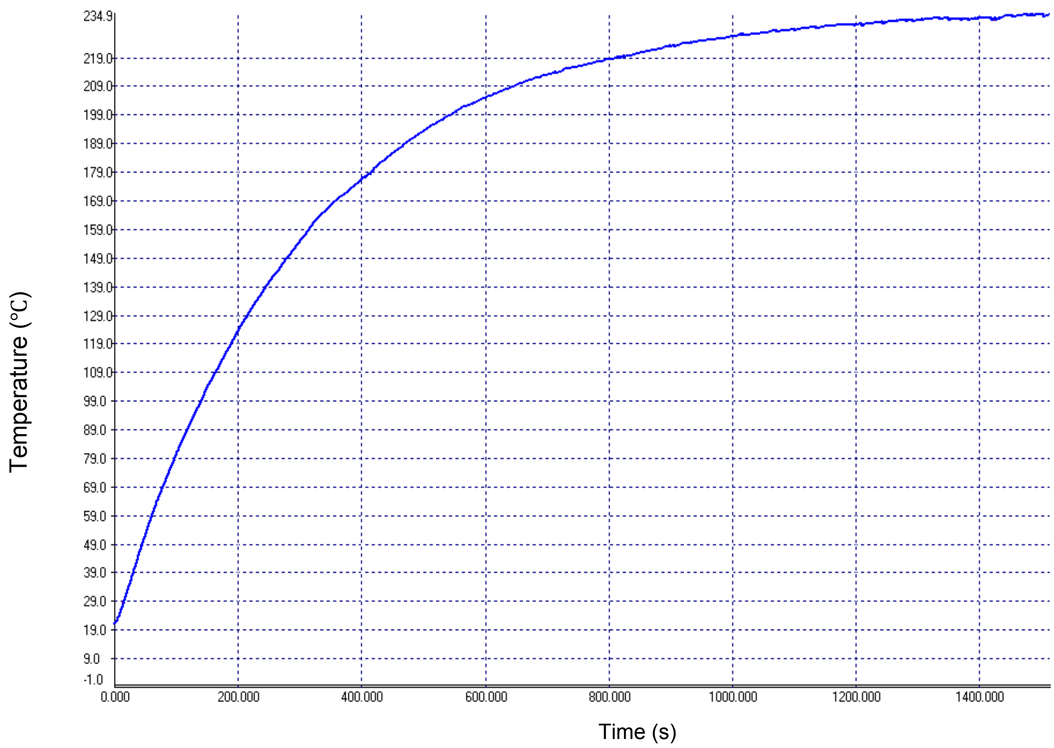

Figure 2: Heating rate of heater 2

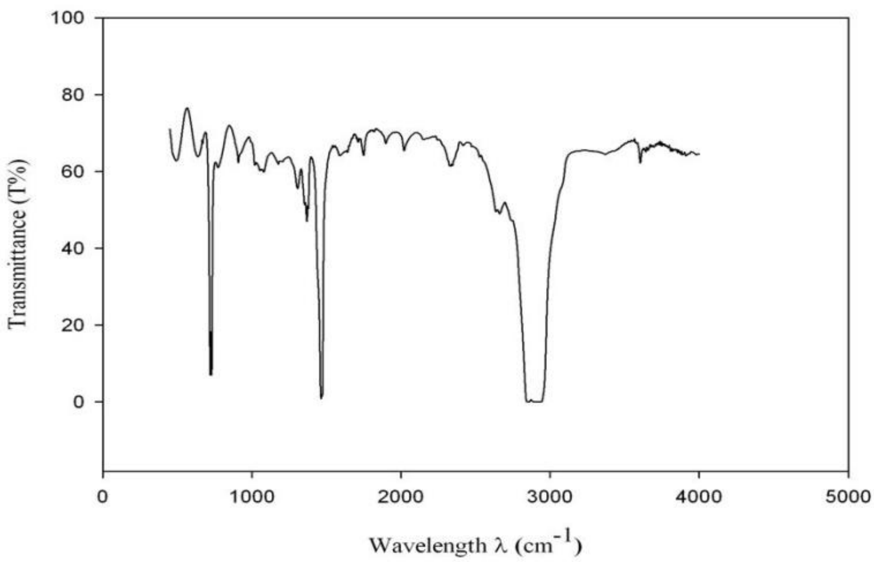

Figure 3: Transmittance spectrograph of LDPE

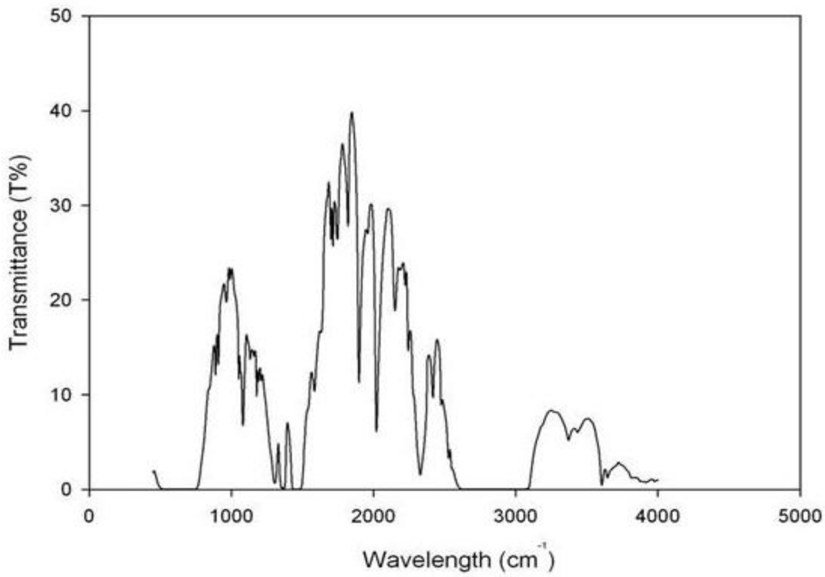

Figure 4: Transmittance spectrograph of HDPE

Table 2: Measured wavelength values

Sample	Measured Peak ValueAbsorption Wavelengths (µm)		
LDPE	3.3	6.6	12
HDPE	3.3	4.5	6.6

4. Results

In order to test and validate the manufactured ceramic infrared heaters for the gasification process and the production of syngas, gasification experiments were conducted. Figure 5 shows the infrared gasifier designed for the gasification tests. The infrared gasifier was left for 20 minutes to reachan operating temperature of457°C. The gasifier was heated to reach temperature of 457°C before feeding the samples to the gasifier. During the gasification of LDPE the emission of syngas started after 10 seconds. Syngas continues to yield for 12 minutes andresults of gasification tests are shown in table 3 below.The temperature measurements inside and outside the gasifier and the temperature of the samples during gasification were performed using a Fluke Ti20 (Thermal imager). The total gas yield of LDPE and HDPE were 96.7wt% and 95 wt% each ata temperature of 457°C. The formation of carbonaceous residue or coke was 3.3wt%, 5.2wt% for LDPE, HDPE respectively.After taking all the plastic samples, the test run is considered finished and the gasification then concluded.

Figure 5: Top view of assembled infrared gasifier

Table 3: Gasification results

Sample	Weight of sample before gasification (grams)	Duration of gasification	Weight of residue after gasification	Maximum temperature of gasifier	Gas yield wt%
LDPE	153.9	12 minutes	5.06	457°C	96.7
HDPE	190.5	10 minutes	9.95	457°C	95.0

5. Conclusion

Gasification results derived from this project were compared to other models, the comparison of the coke residue and the feedstock reveals that carbonaceous residue is very low, which makes the use of ceramic infrared heaters very efficient. The plastics reacted at 457°C because of the good match of the heaters wavelength and the absorption characteristics of the samples. The short gasification times of the plastic samples during gasification confirms the high thermal efficiency of the infrared gasifier and therefore the validity of infrared use in the gasification of plastics. In this experiment the difference in gasification time between samples referred to the difference in samples thickness. Gasification process shows that the amount of the produced gases increased when gasification temperature increased.The comparison has shown that the production of syngas is comparable to models and the designed gasifier has low coke formation less than 5wt%.

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Presenter: This paper is presented by ZuhairHaruon

Senior Projects as a Means of Building Engineering Laboratories

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Abstract

Laboratory experiences are an integral part of undergraduate engineering curricula, but suitable equipment to outfit laboratories can be difficult to procure or too costly for limited department and college budgets. A potential solution to these challenges is to utilize senior projects as a means of building the laboratories. The use of senior projects to build laboratory equipment has benefits for both students and faculty. First, the process of designing, building and testing laboratory equipment satisfies the requirements of a capstone senior design experience for students. Second, students' knowledge of engineering concepts learned in their course work is reinforced. Third, the scholarship of engineering faculty is enhanced through the writing of grants to secure funding for the projects. This paper describes six different engineering laboratories or laboratory apparatus that, under the supervision of faculty, were designed and built by students as their senior projects:

1. *Heat transfer via thermal behavior of electronics*
2. *Air flow chamber*
3. *Air-conditioning system*
4. *Thermoelectric heat pump*
5. *Heat exchanger system*
6. *Shape memory alloys for concrete demolition*

This instructional equipment has become an integral part of the curriculum.

Keywords: *engineering design, senior projects, engineering laboratories*

1. Background

The incorporation of senior projects into engineering curricula to provide students a capstone design experience is well established. A capstone design course not only provides students an over-arching course that encapsulates their engineering program, it also frames their engineering and scientific knowledge in a practical context. Moreover, for an engineering program to be accredited by ABET (Accreditation Board for Engineering and Technology), the program must demonstrate that students have an ability to “design a system, component, or process to meet desired needs” [1]. A capstone design course is typically conducted as a senior project, a year-long senior level course in which a system, component or process is designed, built, tested and documented.

The engineering education literature describing design courses at colleges and universities across the world is extensive. A review of this literature suggests that the disposition of the end product (system, component or process) of the senior project falls within four broad categories. First, the product becomes the property of an industrial sponsor that subsequently uses the product internally or for the public good. Todd et al [2] emphasize that industry is an important customer of engineering education and that students optimally benefit from industry-sponsored projects. Furthermore, Gnanapragasam [3] argues that industry-sponsored projects effectively foster soft skills such as project management, leadership, team work and communication. Second, the product is utilized by the students in a regional, national or global engineering competition. Well known student competitions include Baja SAE, sponsored by the Society of Automotive Engineers [4], American Solar Challenge, sponsored by the Innovators Educational Foundation [5], and Concrete Canoe, sponsored by the American Society of Civil Engineers (ASCE) [6]. Third, the product is retained by the academic department because it consists of equipment or apparatus that supports the instructional needs of the engineering program. For example, Hagen [7] describes a heat transfer laboratory that teaches students thermal behavior of electronics. Mindek et al [8] describe a senior project in which a system for demonstrating solar and wind energy was built. Fourth, the product is placed in storage, surplused, dismantled and used for parts on other projects, or discarded after having served its useful purpose by providing the students a design experience.

This paper focuses on the third category, the use of the product as an instructional tool in the engineering program. Engineering laboratories often require special or custom equipment for teaching specific curricular topics, so suitable equipment to outfit engineering laboratories can be difficult to procure or too costly for limited department and college budgets. Commercial educational laboratory equipment normally costs thousands of dollars, but similar equipment of comparable function and quality can be built by students at a fraction of the cost. The use of senior projects to build laboratory equipment benefits both students and faculty. For students, the process of designing, building and testing laboratory equipment satisfies the requirements of a capstone senior design experience. Students' knowledge of engineering concepts learned in their course work is reinforced by designing and building the very equipment that demonstrate those concepts. Furthermore, the scholarship of engineering faculty is enhanced through the writing of grants to secure funding for the projects.

In the Mechanical Engineering Technology program at Weber State University (WSU), senior projects have been successfully utilized as a means of building instructional laboratories. This paper describes six laboratories that, under the supervision of faculty, were designed and built by students as their senior projects.

2. Description of Projects

The academic and industrial background of the author is heat transfer and fluid mechanics. Consistent with this expertise, fiveof the six senior projects relate to thermal-fluid sciences. The sixth project relates to materials science. Table 1 lists the senior projects, the corresponding courses supported, and the funding sources. As noted in the table, two projects were funded by external agencies, and the rest were funded by a source internal to WSU. All funding was secured by writing competitive grant proposals during the academic year prior to the start of the projects.

Table 1. Summary of senior projects.

Senior project	Courses supported	Funding source
Heat transfer via thermal behavior of electronics	Heat transfer	National Science Foundation (NSF)
Air flow chamber	Fluid mechanics, heat transfer	WSU internal
Air-conditioning system	Thermodynamics	WSU internal
Thermoelectric heat pump	Thermodynamics	American Society of Heating, Refrigerating and Air-conditioning Engineers (ASHRAE)
Heat exchanger system	Heat transfer	WSU internal
Shape memory alloys for concrete demolition	Materials science	WSU internal

2.1 Heat Transfer via Thermal Behavior of Electronics

Of the senior projects listed in Table 1, this project was the most extensive. Funded by NSF, this senior project was conducted by three separate senior project groups during a consecutive three year period. Thermal management of electronics incorporates virtually every fundamental concept found in an undergraduate heat transfer course, making it an ideal application for an instructional laboratory. The heat transfer laboratory consists of nine separate laboratories, each designed to teach a specific heat transfer concept within the context of thermal management of electronics. The laboratory equipment, designed to simulate actual electronic systems at three packaging levels, is shown in Figure 1, and the laboratory structure is summarized in Table 2.

Figure 1. Heat transfer laboratory equipment.

Table 2. Heat transfer laboratory structure.

Lab no.	Heat transfer concept	Electronics application	Electronics packaging level
1	Lumped heat capacity	Transient response of integrated circuits to power-up/power-down	Chip
2	Extended surface	Air-cooling a microprocessor using a pin fin heat sink	Chip
3	Thermal contact resistance	Module clamped to a liquid-cooled cold plate	Sub-assembly
4	Two-dimensional steady conduction	Conduction-cooled circuit board	Sub-assembly
5	External forced convection on plates	Forced air-cooling of a populated circuit board	Sub-assembly
6	Internal forced convection in ducts	Forced air-cooling using a compact-core cold plate	Chassis or sub-assembly
7	Heat exchangers	Cross-flow liquid-to-air heat exchanger for cooling a chassis	Chassis
8	Natural convection from plates of various orientations	Natural convection-cooling of circuit boards	Sub-assembly
9	Surface-to-surface radiation	Radiation between circuit boards	Sub-assembly

2.2 Air Flow Chamber

The air flow chamber is one of the most versatile and widely used apparatus in the thermal-fluid science laboratory. The air flow chamber, shown in Figure 2, is a device used to determine the air flow and pressure characteristics of mechanical systems such as heating and air-conditioning ducts, fans and blowers, air-cooled electronic equipment and air filters. The device consists of a 36-cm diameter PVC pipe through which air is drawn by a centrifugal blower. Flow rate is adjusted by sliding a blast gate across the exit of the chamber. The chamber employs a concentrically positioned sharp-edged orifice which acts as a variable head meter, restricting the flow and thereby inducing a pressure difference across the orifice. The pressure difference is measured by a piezoelectric pressure gage connected to four pressure taps spaced 90° apart around the perimeter of the pipe. This pressure difference is then used to calculate the air flow rate using semi-empirical equations adopted by the American Society of Mechanical Engineers (ASME). The air flow chamber has four different sharp-edged orifices that can readily be changed out through an access port in the side of the chamber. A second pressure gage is connected across the system being tested.

Figure 2. Air flow chamber.

The air flow chamber is used in all laboratories in which a controllable source of air is required. For example, experiments in forced convection heat transfer utilize that air flow chamber because the chamber is capable of delivering a known and controllable flow rate of air across a simulated circuit board or through a duct.

2.3 Air-conditioning System

The purpose of the air-conditioning system, shown in Figure 3, is to teach the vapor-compression refrigeration cycle as part of a thermodynamics course. A version of this cycle is utilized in all standard refrigeration and air-conditioning systems. The device consists of an automotive compressor, a shell-and-tube heat exchanger (condenser), a cross-flow heat exchanger (evaporator) and an adjustable throttling valve. A centrifugal blower forces air through the evaporator.

The device is fully instrumented with thermocouples that measure pertinent refrigerant and air temperatures, pressure sensors that measure refrigerant pressures, and a turbine flow meter that measures refrigerant flow rate. A hot-wire anemometer measures the velocity of air upstream of the evaporator. Tap water is used for the condenser cooling medium. All measurements are displayed by digital panel meters.

Figure 3. Air-conditioning system.

2.4 Thermoelectric Heat Pump

A thermoelectric heat pump, unlike a vapor-compression refrigeration system, can heat as well as cool a space and does so without a compressor, refrigerant or piping. The thermoelectric heat pump is shown in Figure 4. The heart of the heat pump is a solid state device consisting of p-type and n-type semiconductors connected in series and sandwiched between two ceramic plates. When a direct current flows through the device, one plate heats up while the other plate cools down, providing the refrigerating/heating effect. This is known as the Peltier effect. Reversing the current direction alternates the hot and cold sides of the device.

Figure 4. Thermoelectric heat pump.

When a temperature difference is applied across the plates and a voltmeter is placed across the device, a small voltage is measured. This is the Seebeck effect, which is the same principle by which a thermocouple operates, but dissimilar wires are used instead of a semiconductor. If the volt meter is replaced by a load, the device acts as an electrical generator. A thermocouple is installed on each ceramic plate of the solid state thermoelectric module for measuring the temperature difference across the device. Pertinent voltages and currents are measured for the module as well as the heater that induces the temperature difference across the module. All temperature and electrical measurements are displayed by digital panel meters.

2.5 Heat Exchanger System

The heat exchanger system, shown in Figure 5, incorporates into a single piece of equipment three different types of heat exchangers: tube-in-tube, shell-and-tube and cross-flow.

Figure 5. Heat exchanger system.

Students constructed the tube-in-tube heat exchanger by inserting a small copper tube within a larger plastic tube, separating the tubes with a special spacer that permits the flow of water in the annulus. The shell-and-tube and cross-flow heat exchangers were purchased commercially.

The heat exchangers and connecting pipes are mounted on a metal table. Cold tap water is used as supplied for the cold water stream, and hot tap water is heated further using an electrical heating unit mounted on a shelf at the base of the table. For the tube-in-tube heat exchanger, a special flow switch is used to reverse the flow direction of the water thereby permitting the user to demonstrate parallel flow or counter flow operation.

An instrument panel mounted on the back edge of the table incorporates digital panel meters for displaying water flow rates, air velocity and water and air temperatures. Flow rates of the hot and cold water streams are measured using turbine flow meters, and air velocity is measured using a hot-wire anemometer. Thirteen thermocouples measure water and air temperatures at key locations in the system.

2.6 Shape Memory Alloys for Concrete Demolition

Metals and metal alloys have crystal structures that determine their physical properties. When a shape memory alloy is in its low temperature crystalline form, it is easily deformed into a new shape. When the alloy is heated through its transformation temperature, its crystal structure changes, resulting in the recovery of its original undeformed shape, an effect known as "shape memory." During the recovery, the shape memory alloy (SMA) expands significantly. The expansion can be exploited to transmit destructive forces in various construction materials such as concrete and stone. The use of SMAs for the demolition of these materials may be superior to conventional methods using heavy equipment, jack hammers and explosives, which consume large amounts of power and may adversely affect the environment.

Students designed and built a fixture that incorporates up to eight cylindrical specimens of nickel-titanium (NiTi), an alloy that exhibits the shape memory phenomena. The fixture consists of a two steel, tapered half shells that house the NiTi specimens. Electrical cartridge heaters embedded in the shells provide the heat required to raise the NiTi specimens through their transformation temperature. The specimens are first deformed in a 30-ton press, compressing them approximately 3 percent. The specimens are then placed in the steel fixture, and the shells are brought together, holding the NiTi specimens in place. The assembly is snugly inserted into a precast hole in a concrete slab, and the cartridge heaters are powered on. When the transformation temperature is reached, the NiTi specimens expand as they "remember" their original shape, exerting tensile forces on the surface of the hole, thereby breaking the concrete, as shown in Figure 6.

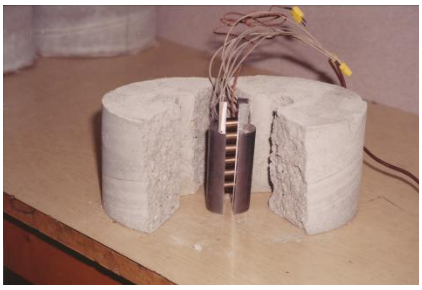

Figure 6. Shape memory alloy fixture.

3. Conclusion

At Weber State University, we have demonstrated that senior projects are an effective means of building engineering laboratories. The use of senior projects to build instructional laboratories benefits students by providing them with a capstone design experience, and benefits faculty by enhancing their scholarship through grant writing. The six senior projects described here provided laboratory equipment that is used on a regular basis and will serve the needs of students for years to come.

4. Acknowledgements

I wish to thank the National Science Foundation and the American Society of Heating, Refrigerating and Air-conditioning Engineers for their support. My thanks also goes to the WSU Research, Scholarship and Professional Growth committee that provided internal funding. Under my supervision, a total of 38 students designed and built the equipment described in this paper. With my thanks, their names and senior projects are give here:

Heat Transfer via Thermal Behavior of Electronics
year 1: Glenn Beus*, Everett Brown, Don Weakley
year 2: Doug Heer, John Martinez, Rooke McKee, Bruce Wilson
year 3: Kim Barker, Brett Ellis, Mark Spencer
Air Flow Chamber: Tim Greenwood, Adam Howard, Rory Howard, Ron Johnson, Margaret Rau
Air-conditioning System: James Grosvernor, Jay Parkinson, Matt Vanderhoof
Thermoelectric Heat Pump: Shawn Heiner, Greg Keiser, Mark Walton, Angelo Paulos, Micheal Whitworth
Heat Exchanger System: Ron Haag, Keith Herrling, Erik Larsen, Gary Phillips, Todd Stokes
Shape Memory Alloys for Concrete Demolition: Rusty Allen, Lori Andreasen, Leslie Daniel, Eric Dowell, Russ Fowers, Dave Hassell, Patricia Lund, Dan Nisonger, Darren Roos, Jared Saleen
* deceased

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Presenter: This paper is presented by Kirk Hagen

Bacterial Cellulose: a Sustainable Material Transformed to be Use in Design

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Abstract

Bacterial cellulose (BC) is the most abundant biopolymer on earth. This is synthesized by bacteria belonging to the genera of bacteria-Aceto, in particular very efficient Gram-negative bacteria, such as Gluconobacter xylinus. To apply the BC in the area of textile design it is necessary to make it hydrophobic. Therefore, the aim of this study was to evaluate the potential of applying very well-known and established finishing processes of textiles onto BC materials, in order to give it more adequate properties to be used as a material for fashion design. Consequently, we used our knowledge about biotechnology and interlink with the knowledge of the textile processes and apply it onto the BC films reaching a hydrophobic material. To assess the success of BC transformation the contact angle test was performed and results showed an increase of approximately 60 degrees, in comparison to BC without any hydrophobic treatment, reaching a contact angle of 118º, a value for hydrophobic surfaces. In addition the hydrophobic BC morphology was examined by scanning electron microscopy (SEM) and compared with pure BC. Finally, analysis of the crystallinity before and after finishing hydrophobic was performed by X-ray diffraction, in order tocheck any change on the structure of the BC.

Keywords: *Bacterial cellulose (BC), hydrophobicity, Sustainability, Eco-Design*

1. Introduction

Sustainability is a critical issue for current and future generations. The fixed idea that natural resources are infinite and that the environment has the capacity to regenerate and compensate for all human action, is no longer acceptable. Consequently, sustainability issues will influence all organizational aspects of human life from the point of view of economic, political, social and environmental. The transformation of human behavior is due to the shift in thinking in relation to resources and unlimited capacity "unlimited world" for regeneration, becoming aware and checking the possibility of termination of resources. It is in this sense that we have to change because these issues encompass all areas of culture, economy, technology and many more. Fortunately, nature and the environment are capable of self-regulation and can give the man a chance to recover [2].

Technology, where much of the production is based, is challenged, along with the culture and the economy, to give the tools and options for building new solutions to a concept of sustainable production [2].

Bacterial cellulose (BC) is the most abundant biopolymer on earth. This is synthesized by bacteria belonging to the genera of bacteria-Aceto, and BC producing bacteria such as Gluconobacter xylinus are more efficient [3].

BC is based on a structure efficiently obtained by a self-assembly forming a network of nanofibers, giving rise to a BC structure that causes a higher crystallinity, higher tensile strength and a large water retention capacity compared to vegetable cellulose, which translates into a very hydrophilic material [4].

In textile industry context, a hydrophobic cellulosic is required because it has a wide range of applications, not only in conventional applications, such as in functional applications like in clothing, waterproof textile stain resistant (oils), among others. The ideal cellulose fabrics for water repellency are the hydrophobic fiber surfaces because they resist to water, with some porosity which allows moisture transport for user comfort [5].

Efforts to reduce the hydrophilicity of the surface of modified cellulose involved different technologies with different efficacies and durability's.

The aim of this study is to generate bacterial cellulose water repellent, or hydrophobic BC, to try to obtain a material with potential application in design, particularly in the textile industry. In addition, a study of incorporation of a softener was performed to improve BC flexibility.

To achieve this we used the knowledge and applications in the textile industry as well as biotechnology safeguarding the best sustainability issues, environmental concerns and costs, allowing the process to be easily implemented extensively in the textile industry.

2. Experimental

2.1. Material

For the production of cellulose, Kombucha xate of BioFermenté, green tea, black tea and sucrose (commercial products) Glucose from RAR, Peptone from Sigma Aldrich, Yeast Extract from Sigma Aldrich, Disodium Phosphate (anhydrous) from Sigma Aldrich and Citric Acid from RAR, were used. For the purification step, sodium hydroxide (NaOH) from Sigma Aldrich and acetic acid (CH3CO2H) from Pronalab, were used.

Hydrophobic commercial products from DyStar textile finishing were gently given in order to obtain the hydrophobic cellulose, the softener agent is EVO Soft Pen and the hydrophobic finishing agent is EVO Wet Fest.

2.2. Preparation of Bacterial Cellulose Pellicles

BC was obtained through a craft production at the University of Beira Interior. The BC is produced in a fermenter comprising an infusion of tea made with 2500ml of distilled water, 4g of green tea, 4g of black tea and 225g of sucrose, boiling until the sugar dissolves [6]. In addition to the tea brewer, we used a liquid culture medium Schramm and Hestrin composed of 10g of glucose, 2.5g peptone, 2.5g yeast extract, 1.35g disodium phosphate (anhydrous) and 0.575g of citric acid in 500ml of distilled water, the medium is autoclaved at 121C ° for 20 minutes [7,8]. After both solutions reach an ambient temperature, they were mixed in a glass fermenter with 250ml of Kombucha xate.

The fermenter is maintained at an average temperature of 30ºC for 7 days. After this period the film is removed and purified in a solution of 0.1N sodium hydroxide for thirty minutes at 80°C to remove the film medium components that were impregnated. This treatment is repeated three times [9], and neutralization comprising 5% acetic acid was subsequently done and finally the film is washed with distilled water [8], thereby obtaining a transparent film.

2.3. Preparation of Bacterial Cellulose hydrophobic

After drying at room temperature, the film was divided into 16 samples weighing 0.013g – 0.014g. The samples were subjected to a preliminary purification by delipidation - BC grease cleaning in order to remove oils, fatty acids and lipids, so that these do not interfere with the setting of DyStar products (softener and hydrophobic finish). The assay was performed by adapting the standard IWTO 10-64, taking into account the characteristics of the film BC.

The extraction of fats BC film with dichloromethane was performed using a balloon and a soxhlet extractor for 2h, so that it works 3 times per hour. In the end, when dichloromethane is found in its entirety in the flask, samples were removed from the soxhlet extractor and dried at room temperature.

After delipidation, a study of incorporation of a softener was performed to improve BC flexibility. Thus proceeded to the placement of four samples in four baths softener with different concentrations to ascertain whether a significant difference existed at the touch/final texture of the film. These baths were composed of distilled water, acetic acid 60% and softener, 0.5ml/l. After 1h of treatment, samples were removed from the bath and drying was performed for 2 minutes in the oven at 40°C. Then we ascertain whether there are significant differences in the touch/texture of the film BC taking into account the different concentrations.

After the softener study, the hydrophobic finishing process, where we used two different methods in order to check whether there were changes in the material behavior, was performed. The first method employed was that is customarily used in the textile industry, 6 BC samples were placed in a bath of 0.5ml softener, and then placed in a bath with hydrophobic finishing agent. These hydrophobic finishing baths were composed of distilled water, acetic acid 60% and hydrophobic product with two concentrations 1.5ml/l and 6ml/l, to check whether there are significant changes in the wettability test. The second method is the opposite of the first, this means, the 6 samples were placed initially in a hydrophobic finishing bath and finally in a softener bath. We followed the same amounts mentioned above for the various finishing hydrophobic baths. The different samples were dried in an oven at 120ºC for 1 minute.

The combination of both treatments are according with the proportions for each finishing agent described on Table 1.

2.4. BC and BC hydrophobic characterization

The assay was performed contact angle Contact Angle System in Dataphysics OCHA 200 with water only in order to analyze the samples wettability of BC and BC hydrophobic.

In addition, the patterns of X-ray diffraction (XRD) were recorded on X-ray diffractometer (Rigaku, D/MAX III/C), in order to verify the crystallinity and microstructure of the samples.

Finally microscopic images were made of BC and hydrophobic BC, through SEM - Scanning electron microscopy - (HITACHI S-2700), to study their morphology. The surface and cross-section of the samples were first treated with gold to be observed in SEM.

3. Results and Discussion

3.1. Material characterization

In this work, we prepared different samples of BC, subjected to a softener treatment along with different concentrations of hydrophobic finishing from DyStar. There were two groups of different samples with respect to hydrophobic bacterial cellulose (hydrophobic BC) since there were two different methods, one method starts with the fabric softener bath and then the hydrophobic finishing bath, the other begins with the hydrophobic finish bath and finally in the bath softener.

The different samples considered for analysis is presented in Table 1, in order to simplify the reading of the results.

Table 1: Bacterial cellulose (BC) and the different hydrophobic bacterial cellulose samples (hydrophobic BC) according to the concentrations used.

Material	Method	Softener Quantity	Hydrophobic Product Quantity
Bacterial Cellulose (BC)	*Kombucha tea + Schramm and Hestrin medium*	-	-
Hydrophobic Bacterial Cellulose (Hydrophobic BC)	*Softener bath + Hydrophobic finishing bath*	0,5 ml 0,5ml	1,5ml 6ml
	Hydrophobic finishing bath + Softener bath	1,5ml 6ml	0,5ml 0,5ml

3.2. Contact angle

The contact angle test was performed on Dataphysics Contact Angle System OCHA 200 (Fig. 1a), in order to verify the results of the hydrophobic treatment (DyStar), and check which of the quantities introduced best suits the goals.

The samples were all cut to the same size with the help of a guillotine and then placed on the display, in a linear and homogeneous form, and a droplet (5μl) was subsequently deposited and a film instantly started to record the drop behavior (fig.1b) and absorption after 10s, in order to give information about the wettability of the samples. All results were transferred into computer so as to obtain numerical results of the absorption.

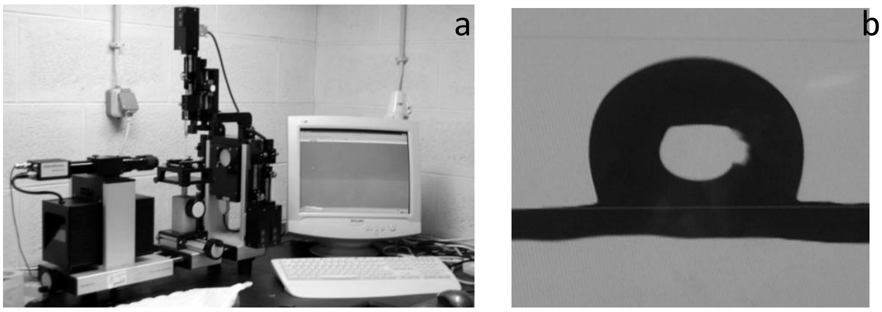

Figure 1. The equipment used for measuring contact angles (a). Image obtained by filming the device, the placement of the drop on the hydrophobic BC (b).

Six trials were performed for each condition, which allowed us to verify the homogeneity of the sample and its hydrophbicity. The use of two different methods, namely the use of initial softener and then the hydrophobic finishing, and on the other hand the use of hydrophobic finishing and finally aimed softener was done to check if there was any change of behavior of the material, knowing that in the textile industry the method is the use of softener and then the hydrophobic finishing. Likewise, the modifications of the material as the touch and texture were not significant regarding the behavior of the material.

In contrast, the average of all the tests concerning the contact angle showed a different behavior and the results can be seen in Fig 2, so that it can be checked the most advantageous condition in accordance with the purpose of this work in achieving a hydrophobic material.

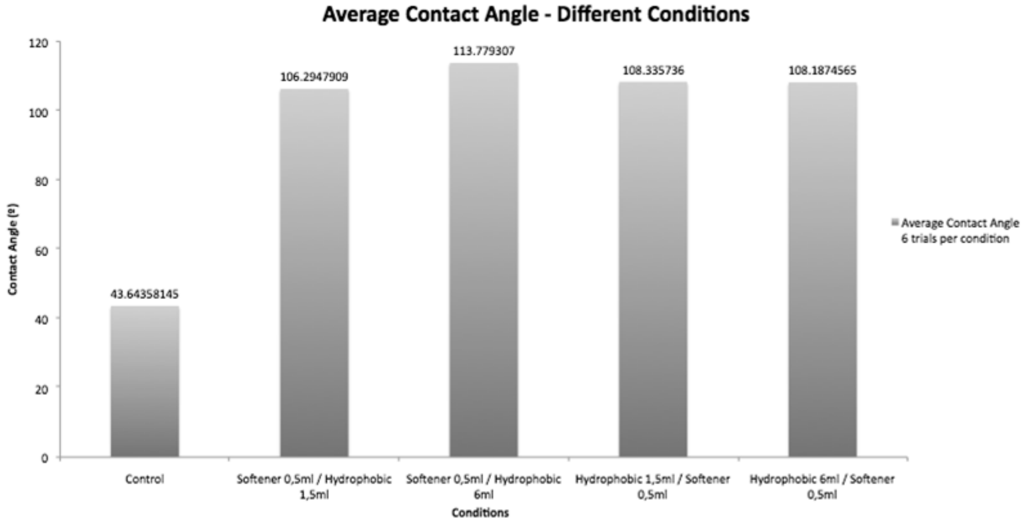

Figure 2. Average Contact Angle of BC and hydrophobic BC, taking into account the different conditions.

According to the method used in the textile industry, the use of softener and finally the hydrophobic finishing proved that achieves best results when referring to the hydrophobicity of BC. At the higher concentration of the hydrophobic finishing agent BC becomes more hydrophobic. However it is possible to verify that any application abled to achieve a more hydrophobic BC, in comparison with pure BC.

3.3. X-ray diffractometry (XRD)

The X-ray diffraction was used to study the crystallinity and microstructure of the samples from pure BC and hydrophobic BC. The spectra shown in Fig.3 regarding to BC obtained before and after treatment, showed the peaks corresponding to the typical profile of amorphous cellulose I [10].

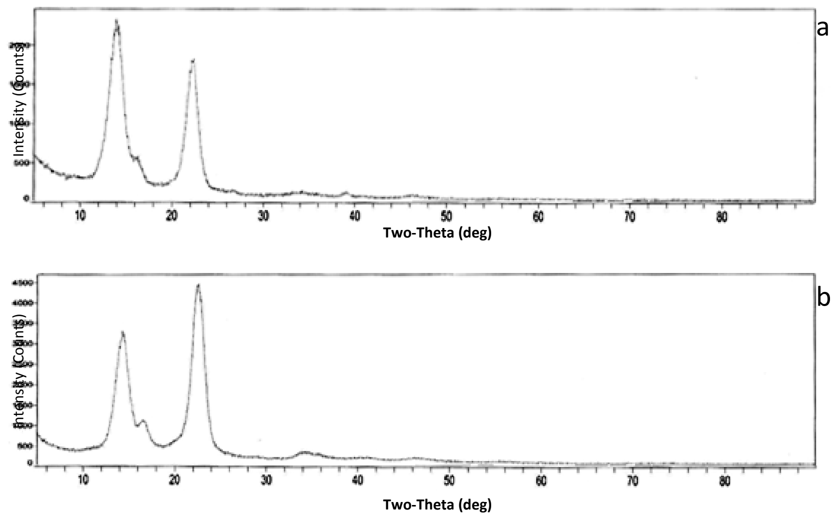

Figure 3. Images of Bacterial Cellulose XRD (a) and Hydrophobic Bacterial Cellulose (b)

However, compared to the XRD profiles of vegetable cellulose [11] those peaks show differences in intensity.

This difference may indicate the difference of the processes of biosynthesis. Examining the plant cellulose, is usually synthesized by terminal clusters, whereas bacterial cellulose produced by bacteria of the family Gluconobacter is synthesized in linear terminals. The plant cellulose does not have a preferential plane, which means it has different levels, unlike bacterial cellulose having a preferential plane, where the cellulose molecules are oriented parallel to the plane, identified as tendency guidance "uniplane" [10,11]. The peak is sharper for hydrophobic BC than for pure BC, then the average value of the crystallinity index (CI) of the hydrophobic BC is slightly larger than that of the BC film.

The treatment does not alter the hydrophobic BC amorphous structure, compared to the BC peaks, which are sharper in the hydrophobic BC, which translates into an indication of the higher degree of crystallinity in the structure of the treated sample. The similar increase of crystallinity was detected by other authors [12] for samples of film treated by combining the effects of pressure and temperature, whereas the decrease of the porosity in the film leads to overall higher crystallinity.

3.4. SEM image observation

Fig. 4 shows the SEM images of BC and hydrophobic BC. As it can be seen from the figure, BC nanofibrils can be observed on the surface in a multilayered structure, thus verifying a structure of well-organized three-dimensional network.

The biosynthesis of cellulose is characterized by growth in a single direction of crystallization, which verifies that the molecules are linear glucose, connected by β (1 → 4) glycosidic connection. The combination of glycosidic chains form microfibrils oriented with intramolecular hydrogen bonds [13]. The growth mechanism during bacterial activity determines the morphology of the final film.

After the hydrophobic treatment, the surface morphology of BC was changed. Hydrophobic BC unable the observation of nanofibrils as BC, and this change is due to the hydrophobic coating layer deposited on the treated BC forming a thick layer. With this coating layer the BC pores were sealed making it an hydrophobic layer.

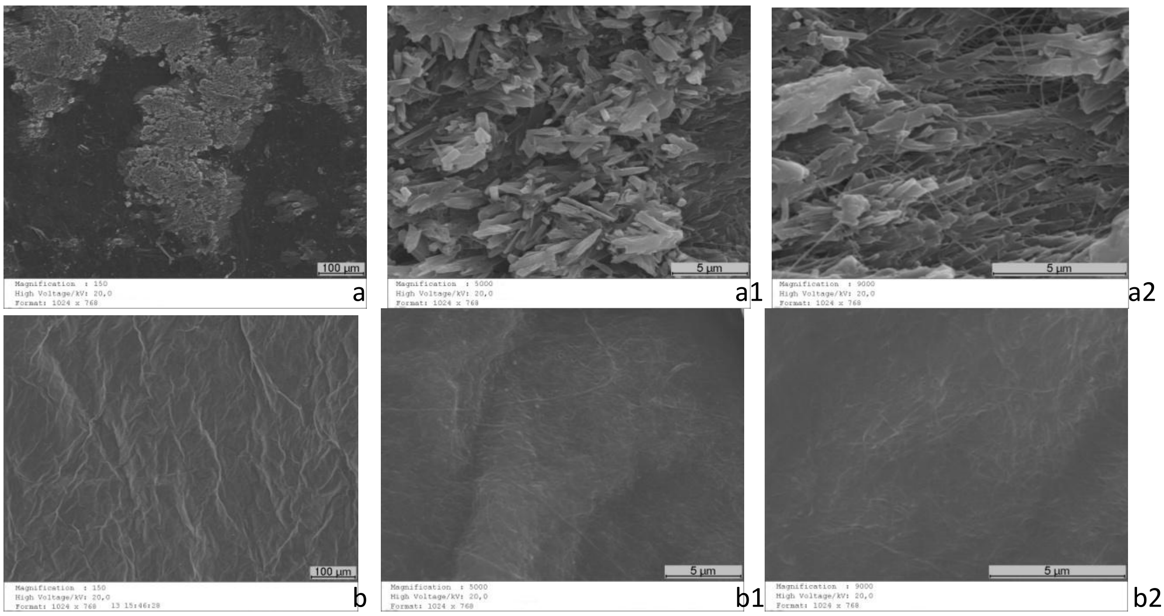

Figure 4. SEM images of Bacterial Cellulose (a) and Hydrophobic Bacterial Cellulose (b).

4. Conclusion

The hydrophobic BC was prepared by immersing the film in a solution of BC softener solution followed by a hydrophobic finishing. The test of the contact angle achieved in this way proves hydrophobic BC and that is possible to obtain hydrophobic BC with minimal quantities of hydrophobic finishing agents.

With these results we can see that besides the added value to make BC a hydrophobic material it can be also obtained a more homogeneous surface morphology with a more uniform fiber surface.

According to these results, it is expected that the hydrophobic BC may find interesting applications in design, such as the application of textile material in clothing, flooring and other interior design materials.

5. Acknowledgements

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Presenter: This paper is presented by Silvia Araújo

Agile Methods in Competitive Systems Development

Towards Improved Understanding of Learning Practices used in Scrum Software Development Projects

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Abstract

Agile organizing practices such as Scrum have emerged out of the need for lightweight software development practices that are better equipped to deal with demands of modern economies such as dynamic business requirements and rapidly evolving technologies. Agile's break away from traditional software engineering practices represents a shift in thinking in software project management from a more deterministic paradigm to one that embraces change and the learning that accompanies change. These learning practices remain largely unexplored and under-theorized. This paper proposes that organizational learning theories of Argyris and Argyris and Schön form a worthy theoretical lens to study the learning practices taking place in Scrum software development projects. This is illustrated by a preliminary case study of a software development team practicing Scrum. Some learning practices are identified and reflected from the perspective of this theoretical lens. Although these learning practices have always existed in agile software projects this paper aims to bring about theoretical support to elucidate them. This work contributes towards the growing body of knowledge of alternative organizing paradigms in software development.

Keywords: *Agile Software Development; Scrum; Organizational Learning; Model 2 Theory-in-use*

1. Introduction

Agile software development emerged as a response to modern business needs which are typically characterised by rapidly changing market driven requirements and competition. In an attempt to stay abreast of this growing economic trait, information systems development (ISD) has evolved from a plan driven mind-set to one of adaptability, innovation and increased client involvement. The agile manifesto enshrines values and principles that form the underpinning for most agile management approaches. One such approach is Scrum.

Scrum is arguably one of the more popular agile management frameworks in use [1]. Often defined as a lightweight management framework, Scrum exhibits potential advantages over plan driven approaches to software projects in its ability to absorb sudden change in project characteristics such as business needs or technology [2, 3]. This equips Scrum as an organizational pattern that is designed for control of an activity that is highly unpredictable [4].

Scrum can be perceived as management through organizing [5] due to more emphasis being placed on facilitating responsibilities associated with self-organizing, autonomous work allocation, and multidisciplinary teams [6]. Scrum teams typically set their own development targets and decide how best to achieve them. These traits often require practices and techniques that enhance learning processes between constituent stakeholders immersed in the ISD project. Within a typical Scrum project, learning may be influenced through initiatives such as an open plan environment [7] or practices such as, daily stand up meetings, sprint retrospectives, and sprint demonstrations [8]. Despite this practitioner

acknowledgment of inherent learning, this paper posits that Scrum is only just beginning to feature in wider academic debates on learning, organizational learning, and learning organizations.
Organizational learning is the field of enquiry which explores the concept of learning among individuals and organizations [9, 10]. Despite a long and illustrious academic history, a concise definition of organizational learning remains elusive [11, 12]. Argyris and Schön jointly present some of the most widely adopted theories for understanding individual and organizational learning. In this paper, their definition of individual and organizational learning is adopted: the detection and correction of error whereby error is a mismatch between what is intended and what is produced [13]. The authors associate organizational learning with behavioural development "But if learning is to persist, manager and employees must also look inward. They need to reflect critically on their own behaviour, identify the ways that often inadvertently contribute to the organization's problems, and then change how they act." [14]. This motivated the development of the organizational learning theories such as Model 2 theory-in-use which sought to uncover characteristics which germinates effective organizational learning.

Very few studies have been found investigating organizational learning theories in context of agile or Scrum ISD projects. Hence, this pilot study aims to identify whether Scrum practices in a small South African SMME fit the criterion for Model 2 theory-in-use learning. To the best of our knowledge, this connection has never been established in the literature. For this reason our study seeks to understand whether Scrum practices trigger a learning process consistent with the criteria established in Model 2 theory-in-use. It should be noted that this study does not set out to empirically measure the extent of learning taking place in a Scrum project environment.

This pilot study verifies the presence of Model 2 theory-in-use characteristics in the observed Scrum practices. From this observation it is inferred that Scrum management practices fit the criterion for effective organizational learning as specified in [13].

This pilot study consists of qualitative analysis of observed and interview data for a period of six weeks. There was minimal participation in Scrum project activities. Interviews were held with some members of the project team to clarify observed data. Data analysis was done using a grounded theory open coding approach.

The rest of the paper is organized as follows. In section 2 we review literature related to Scrum management framework and organizational learning theories by Argyris and Schön. Section 3 describes the research methodology. In section 4, we present data analysis. Finally, in section 5, the conclusions and future research are presented.

2. Literature Review

Scrum is a management framework of best practices for agile ISD and should not be interpreted as a formal, prescriptive methodology [15, 16]. It is based on Lean development principles which were first introduced in the manufacturing area [17] and is also influenced by the area of knowledge management [16, 18]. Given this heritage, practitioners often acknowledge Scrum practices as stimulus for learning. Managing a Scrum ISD project requires aptitude in traditional project management concepts such as cost, schedule, and planning [19, 20] albeit in different formats. More importantly, emphasis is placed on facilitating team learning throughout the project. This has led to a steady rise of agile ISD in debates on learning, organizational learning, and the learning organization. Some related studies explore the link between organizational learning and agile adoption for ISD [21, 22], organizational learning and inter-team process improvement [23-25], knowledge transfer between agile team and the encompassing organization [26], organizational learning and multi-project agile practices [27], organizational learning and information technology implementation [28], and reflective-practice and learning within agile teams [29]. This paper adds to this growing knowledge base by exploring connections between Scrum management framework practices and organizational learning theories.

2.1 Scrum Management Framework Practices

Scrum is one of the more popular agile ISD management frameworks evident from numerous reports that praise Scrum on its management approach [2, 30, 31]. Scrum is a good starting approach for organizations with small teams and ill-defined processes as Scrum practices allows for a degree of flexibility and adaptability [32]. Despite this popularity, Scrum is not a prescriptive framework hence manifestations may vary across projects, teams, and companies. However, the practices appear with few variations. Typical practices performed in the Scrum management framework are summarised in the table below. These are derived from [1, 33, 34] and Scrum support websites [35].

Table 1: Typical practices performed in the Scrum management framework

Scrum Practice	*Common Activities*
Create Product Backlog	Product owner together with project clients and other stakeholders decide on business requirements. This is communicated as prioritized user stories on a product backlog which becomes the product. Product backlog evolves throughout the project.
Sprint Planning	Occurs before each sprint. The development team members decide on the user stories from the product backlog to be developed during the sprint. The team may seek clarity user story requirements from the product owner before selecting user stories. Each user story is designed and broken into prioritized units of work and communicated via a sprint backlog.
Sprint	A product development cycle. Usually lasts 3-4 weeks. Start and end dates are fixed.
Daily Stand Up meeting (Scrum)	Daily progress report. Scrum master is usually chair. Short meeting where development team presents work done, work in progress and report on difficulty.
Sprint Demo	Inspection of software artefact by client. Product owner, developers, scrum master and clients and other stakeholders are present. What should be developed next is discussed after demo.
Sprint Retrospective	Development team reflects on the sprint and identifies areas of improvement and agree on ways to improve. This is a reflective and forward planning session.

The next section will examine organizational learning theories and Model 2 theory-in-use characteristics.

2.2 Organizational Learning

Argyris and Schön are the more recognized advocates for the field of organizational learning. There are three cornerstones to their contributions namely, theories of action (espoused theory or theory-in-use), categorisation of governing values that underlie theory-in-use (Model 1 and Model 2), and model of learning cycles (single loop and double loop).

Theory of action is based on the epistemology that the actions individuals take are not accidental but a product of their mental design [13]. These mental maps are acted out to achieve desired end results. Two theories explain this process of designing and taking action namely, espoused theory and theory-in-use [36]. Espoused theory relates to tacit structures and values that govern actions. For example, understanding of good grammar and its influence on speech and writing patterns. During their extended empirical work, Argyris and Schön noticed that for the vast majority, participants' actual action did not always match their espoused theory. Stated more simply, participants didn't always practise what they preach. This seemingly irrationality of actions is referred to theory-in-use. An example of this violation is the action taken by humans to avoid embarrassment despite it contravening their beliefs. This may be viewed in context of a natural defensive mechanism in the face of threat, need for self-protection, or to save embarrassment [37].

The authors stress that individuals should acknowledge this difference such that defensive mechanisms are removed. During their empirical work models of the process of taking action were created. This afforded participants with a mechanism to better understand their theory-in-use [14]. The components are described in the table below.

Table 2: Theory-in-use model components

Governing values	A range of values that individuals seek to satisfy. The action taken by individuals is often a trade-off between governing values i.e. whereby the value of one is raised at the expense of lowering the other
Action strategies	Actions that the individual believes are necessary to satisfy governing values
Consequences	Observed results of actions within the environment

Unintended consequences that do not satisfy governing values usually trigger a response in the form of either a single loop or a double loop learning cycle. "Single loop learning involves the generation of new action strategies to achieve existing governing values. Double-loop learning, on the other hand, involves adaptation and modification of the governing values themselves" [38]. Double-loop learning needs to be promoted in preserve of effective organizational learning [39]. A simple diagram to illustrate follows.

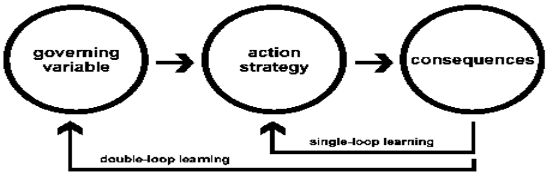

Figure 1: theory-in-use and learning cycles

Model 1 and Model 2 theory-in-use were deduced from vast empirical work by Argyris and Schön [13]. Each model has differing characteristics of governing values, action strategies, and consequences. Characteristics of governing values and action strategies are indicative of whether behaviour lends toward organizational learning. Space constraints do not permit full discussion of Model 1 theory-in-use. Briefly, Model 1 characteristics often lead to behaviour consistent with defensiveness and error. Hence, it does not fully support effective organizational learning. Model 2 characteristics are more desirable. "Briefly, this [Model 2] theory-in-use is designed to enhance the kind of individual and organizational learning to which we have been alluding" [14]. Model 2 theory-in-use characteristics are shown in the table below.

Table 3: characteristics of governing values and action strategies and desirable consequences

Governing values	Action strategies	Consequences for Learning
a. Valid information	a. Create environments whereby team can contribute freely and experience high psychological success	a. Dynamic Processes
b. Free and informed choice	b. Tasks are controlled jointly	b. Double-loop learning
c. Internal commitment to the choice and constant monitoring of its implementation	c. Advocate view but allow for inquiry and public testing	c. Public testing of theories
	d. Minimize bilateral protection of team i.e. embarrassment and threat are not hidden but engaged	

Behaviour congruent with Model 2 theory-in-use result in dynamic processes, more desirable double-loop learning and public testing of theories. This in turn creates an environment suitable to germinate effective organizational learning.

3. Research Methodology

This study is classified as an exploration of Scrum management practices (explicated in Table 1) as seen through the lens of Model 2 theory-in-use [40]. It focuses on Scrum as a management framework for an ISD project and incorporates the practices and interactions necessary to build the software product. The case presented in this paper is an exploratory case study or pilot study aimed at examining a topic scarcely studied before.

3.1 Research Question

Do the practices embodied in the Scrum management framework exhibit characteristics of Model 2 theory-in-use? If 'yes', how are they evident?

3.2 Case Study Description

A South African based software development SMME volunteered participation. An ISD project managed via Scrum formed the pilot case study. The researchers were granted access to entire scope of the project. The development team comprised a product owner, scrum master (one for the whole company), on-site client representative (the client was a large international based corporation), and seven developers. One of the researchers participated in the ISD project from sprint 2 until the end, a period of 12 weeks.

3.3 Data Collection and Data Analysis Approach

The researcher attended all daily stand-up meetings, retrospectives, planning sessions, and performed limited user interface testing. This allowed a closer relationship with the team. Detailed field notes were made throughout. Video recording would have been the ideal approach however, this request was declined. Interviews were held with certain team members a short while after the fieldwork to iron out uncertainties in the recorded observations. Analysis of the data was done via open coding from the grounded theory approach [41, 42].

4. Data Analysis

The results from the pilot study reveal that Model 2 theory-in-use characteristics could be observed in most of the employed Scrum practices. Space limitations prevent a comprehensive listing of analysis. Instead, recurring behaviours aligned with Model 2 theory-in-use is presented in the table below. The table below lists some transcripts of observation notes.

Table 4: Transcripts of observed behaviour aligned with Model 2 theory-in-use characteristics

Observed Scrum Practice	Observed Model 2 Governing Value	Evidence of Model 2 Action Strategy			
		Create environment whereby team can contribute freely	Joint control of Task	Advocate view but allow for inquiry and public testing	Minimize bilateral protection of team i.e. embarrassment and threat are not hidden but engaged
Backlog Planning	Valid Information Internal Commitment	Workshop format with open discussion for clarification of	Backlog was developed by client, product owner, and one/two	Uncertainties and misunderstandings of requirements were admitted early	Product owner and developer freely admitted that they were unclear on

	and constant monitoring	product requirements	developers	This triggered discussion between the product owner, client, and developers	some areas of the client business
Sprint Planning	Valid Information Free and informed Choice Internal Commitment and constant monitoring	Team was provided with autonomy to set goals that balanced acceptable project velocity and exploration or "up skilling"	Team was responsible for planning delivery of user stories for sprint Team cross checked with the Scrum Master to ensure project remained profitable	Uncertainties were openly admitted and this afforded clarity from the product owner before committing to sprint plan At the end of the process the entire development team was given opportunity to comment	During this process the developers in charge often conferred or asked opinions of the team In some cases comments from the team resulted in revision/rework which was not frowned upon
Sprint	Valid Information Free and informed Choice Internal Commitment and constant monitoring	Development work took place in an open office which encouraged informal communication Kanban as visual aid for progress evaluation	Development work was sometimes done via pair programming Developers voluntarily offered assistance to tasks lagging behind.	Quality was adhered to by team subjecting code for regular reviews Open plan office allowed for easy access to help or opinions from peers	When difficulty was experienced, developers asked for help via pair programming
Daily Stand Up	Valid Information Internal Commitment and constant monitoring	Scrum master provided an opportunity for all to communicate their progress and problems	Scrum master reported his concerns about lagging schedules Based on this developers chose tasks where they were more skilled Developers selected their own user stories	Team members openly conveyed difficulties and uncertainties, no matter how trivial	Developers having difficulty with a user story publically asks for assistance Scrum master invited suggestions and sometimes provide relief in the form of adding one/two more developers Sometimes the product owner was present to

					provide instant clarification on user stories
Sprint Demo	Valid Information Free and informed Choice	Client contributed openly to the showcased software artefact Developers and product owners responded to criticisms and queries	Demonstration was interactive whereby client could utilise software artefact with help from developer Product owner and developer responded to questions on functionality	Client encouraged to voice "frank and honest" opinions with regards to uncertainties, functionalities, or difficulties in use When asked why a certain aspect was done so, product owner explained "that was our understanding"	Criticisms from client were carefully recorded and did not seem to damper developer morale
Sprint Retrospective	Valid Information Free and informed Choice Internal Commitment and constant monitoring	Team expressed their views on reasons for experienced difficulties Each member voted on the severity and priority of problem At times this practice exhibited characteristics of a support group	Developers, product owner, client representative, and scrum master contributed equally There were no signs of forced impetus from senior company employees	Each participant voiced their opinion freely which triggered debate on each Some views were deemed simple misunderstandings which were "ironed out" by elaboration from the team Problem areas identified by majority vote were converted into strategies for testing during next sprint	The team did not shy away from unearthing underlying issues that serve as "roadblocks" Team openly admits that they have a lot of room for improvement Developers often admitted to their limiting traits

These observed interactions between team members and practices fit the criterion for Model 2 theory-in-use. Model 2 theory-in-use governing values are also evident in the observed practices. However, it must be taken into account that this table does not represent all instances of observations. Some observed behaviour did not fit Model 2 theory-in-use characteristics. On one occasion, during the sprint demo, the product owner and developer realised that they had misinterpreted a functional aspect. They blamed this on the lack of feedback from the client even though this was not true. Another example was when the Scrum master stated in an interview with the researcher that allocation of tasks was left entirely to the team. However, there were a handful of observed instances when user stories were handed to certain developers due to complexity and a lagging project schedule. Overall, the Model 2 theory-in-use characteristics were more frequently observed compared to Model 1 characteristics.

5. Conclusion

In this paper, we review the learning and organizational learning theories developed by Argyris and Schön to establish a link between Scrum management practices and Model 2 theory-in-use. We then map the practices of Scrum to the characteristics for Model 2 theory-in-use. Within this pilot study, evidence of Model 2 theory-in-use is evident. Governing values and action strategies aligned with Model 2 theory-in-use was identified in most of the employed Scrum practices. A wider conclusion is that Scrum management practices more easily portray characteristics of learning organizations compared to traditional software engineering. Although this study was limited, there is sufficient evidence to warrant further and more robust investigations into application of organizational learning theories in area.

6. Limitations and Future Research

The first limitation of this study is its preliminary nature and shorter immersion in project context. Secondly, in order to fully test learning theories, change in behaviour needs to be observed. This is not possible in shorter, preliminary contexts. Thirdly and finally, this study focused on one aspect of Argyris and Schön work namely Model 2 theory-in-use. Future research should aim at exploring their other theories on organizational learning work in Scrum contexts. Possibilities include an expansion to include the concepts single-loop and double-loop learning cycles and how they occur in Scrum project contexts. Schön provides a model of the reflective practitioner which also has promising avenues to better understand the process of behavioural changes among Scrum development teams. When compared to other observations, the sprint retrospective appears a richer practice in terms of its influence on learning. This practice represented the highest concentration of Model 2 theory-in-use behavioural characteristics and represents an area in need for deeper exploration. Ultimately, future studies should strive to include wider debates on communities of practice and its influence on learning in emerging management contexts.

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Engineering, Design and Technology for Developing Countries

Engineering Profession for Sustainable Innovation in Developing Countries.

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Abstract

For any economy to strive for sustainable innovation, the engineering profession must be given its rightful place. This is the profession that drives the economy of any nation. The awareness, impact and training, need to be evaluated without which the role or relevance of engineering will not be noticed. The engineering profession and engineering infrastructure must be sustained and updated to enhance industrialization for any Nation's economy for global competitiveness. In many developing economies, engineering is not seen as the driver of the economy. Engineers are used and dumped many a times. In view of this, it is the aim of this paper to discuss the engineering profession in terms of positive innovation mostly in the developing countries, as a case study. For sustainable innovation to strive, the engineering profession must be taken seriously by stakeholders as regards funding engineering education, providing adequate engineering infrastructure, manpower development, poverty reduction through entrepreneurship and creating an enabling environment for engineering practice.

Keywords: *Sustainability, University Education, Innovation, Industrialization, Entrepreneurship, Poverty Reduction.*

1 Introduction

Sustainability is the concern of the environmentalist in the first instance, but judging from the current environmental challenges; greenhouse gas emissions, earthquakes, deforestation, manufacture of mass destructive weapons, disturbance of the ecosystem in the name of research and development, etc the issue sustainability in the 21st century has become today a concern to all professions. The world's population grows at an explosive rate; it becomes difficult to strive for higher and higher standards of living without depleting the limited resources of Earth and its inhabitants [1-4]. Therefore, the efficient use of the available resources is imperative if human existence must continue on the planet Earth. It is important to note that, the engineer or the engineering profession in any society is directly involved in the sustenance of the earth for human habitation. Although, sustainability is difficult to define in clear terms, it is important we suggest a definition:

- Sustainability is defined as, '*meeting the needs of the present without compromising the ability of future generations to meet their needs* [5].
- Sustainability is also defined as *'design of human and industrial systems to ensure that humankind's use of natural resources and cycles does not lead to diminished quality of life due either to losses in further economic opportunities or to adverse impacts on social conditions, human health and the environment'* [6].

Engineering which is the application of science to designing, planning, construction and maintenance of buildings, machines and other manufactured systems [7], is seen as a vital tool for improvement of the standard of living of a society. In Phillips [8], Engineering is seen as the profession that utilizes the knowledge of mathematics and natural sciences gained by study, experiment and practice applied with judgment to develop ways to utilize, economically, the materials and forces of nature for the benefit of mankind. It is seen as the driver to the socio-economic development of a nation, a noble profession that builds a great and noble work force that any Nation can be happy to have. It embraces all aspects of human activity like; Health, Transport, Communication, Agriculture, Environment, Energy and Power. On a daily basis the society experiences one problem or the other in the above mentioned areas of engineering application. Engineers sit back to proffer solutions to these problems by designing, constructing and maintaining systems, and creating innovative ideas to improve system efficiency and performance. Combining the two definitions above, we can now suggest that, sustainability is defined as, 'the application of engineering to create comfort today and beyond without any adverse effect on the future existence of humans'. Engineers are therefore careful in proffering solutions today that will not destroy the comfort of tomorrow. In trying to do this, the concept and elements of sustainability are brought to bear. Sustainable and innovative engineering is solicited in the whole world, therefore, the engineer must be equipped well enough to render such services to the society. The question that readily comes to mind is; 'is it possible for our educational and research institutions with their present curricula to revise their curriculum to include the theory and principle of sustainability' which is sustainable and innovative engineering? The answer is; revising the engineering curriculum is long overdue and the necessity for change cannot be overemphasized. The change must include the dynamic technological changes. In some aspects of our engineering innovations, if allowed to continue can destroy the world in the few years to come.

For the engineering profession to maintain its dignity, priority should be given to research having a higher percentage of local content with minimal cost [9, 10]. When the engineer understands his society, research becomes a hobby and not a task. Quality of engineering education results in quality engineers in society, not expatriates but indigenous. Modalities must be put in place for procedural takeover by indigenous engineers from the expatriates [11, 12]. As society continues to survive on planet earth, greater understanding of the planet is sought. Nations seek to move towards self reliance and security of their sovereignty. The involvement of the engineering profession in the realization of these aspirations yields faster results [10].

2 Challenges of the Engineering Profession

In the developing countries like Nigeria and even developed countries, the engineering profession is confronted with challenges. From the type of training to the practice of the profession, the societal perception of an engineer creates worse situations to the engineer in society. Some of the challenges militating against engineering profession and practice include the following:

2.1 The type of Engineering Education

Nigeria, a country with 36 Federal Universities, 36 State Universities and about 45 private Universities [4], lacks adequate engineering personnel to undertake engineering practice. This is unacceptable to a country like Nigeria. This situation calls for urgent redress concerning the curriculum of engineering in Nigerian Universities. Most of these Universities don't have enough and adequate infrastructure for teaching and learning of engineering. It is recommended in this paper that, the Nigeria government should select at least twelve out of the 72 that exist, two in each geo-political zone and raise these twelve Universities to world standard. The accreditation of University programs by the National University Commission (NUC) should be taken seriously. Any University that cannot meet the minimum standard should be asked to close down. Accreditation of engineering programs should be undertaken by both national and international Engineers/professors. This will create sanity in the program accreditation process.

2.2 Local content driven economy

One of the facts usually overlooked in terms of meeting the Nigerian Content directives is in terms of proper empowerment of our institutions of higher learning to be in the forefront in this matter. This means that all our departments should be adequately equipped with financial, human, teaching and research resources. In this case the era of lip service in terms of adequate tertiary institutions' funding has passed and adequate budgeting must be made for tertiary institutions to ensure that their mandates are fully met [11, 12]. The financial needs would have to be met by a more realistic government subvention, students without scholarships would have to pay more than they are currently paying, and more government scholarships have to be awarded to deserving candidates. Apart from government subvention, many other avenues must be sensitized to their responsibilities in providing functional education. Local content driven economy is to redirect the nation's interest to indigenous product and services. This means that, products that are locally manufactured must be appreciated, desired and made use of by citizens. Technology transfer must identify areas of comparative advantage and develop local technology for the manufacture of such products. Of course, there must be funding for such innovation. Research with a high percentage of local content should be funded and commended.

2.3 Engineering Entrepreneurship Poverty Reduction

In 2011, the education sector included Entrepreneurship in the curriculum of both the undergraduate and graduate programs in the Universities. The inclusion of entrepreneurship in the University program is to equip mostly engineers to be employers of labour at graduation. This in effect will reduce unemployment and reduce the poverty level in society. The engineer at graduation must have developed skills to practice engineering. But, this is not the issue, enterprising on the knowledge acquired, with the help of credit facilities at minimal interest rate will industrialize the society and create jobs for the teeming population of the country. For example, in Cross River University of Technology, Calabar, Nigeria, in 2012 included renewable energy and energy management to be an option in the postgraduate programs in the department of Electrical/Electronic Engineering. This also is another way of equipping the 21st century engineer with skills for enterprising. The entrepreneurship developed by the engineer is driven by sustained innovations. Renewable energy systems are becoming a good contender in the power sector. The total dependence on the conventional energy sources with population increasing at an alarming rate without corresponding increase in the resources, causes the depletion of those resources. This means that in the near future, the energy sector will not be sustained. This is why other potential energy sources are being sought to improve the energy sector, that are sustainable.

3 Engineering Educations' Strategic Plan Model

The strategic plan model is shown in figure 1, is a suggested strategic plan to assist in the training of the engineer in society for sustained innovation. The training of engineers or running engineering institutions is an expensive business; therefore, it is proposed here that there should be a collective responsibility by stakeholders to promote sustainable innovation. Invention and innovation start with an individual and spreads, but, the concern of the society is that such invention or innovation should be sustainable. Different aspects of the economy deserve attention in this regard. In the energy sector, renewable energy has become a global issue due to climate change and global warming. Therefore, to sustain and protect the earth and the ecosystem, engineers and scientists should through research proffer solutions to climate change. Due to security challenges, terrorism and national conflict around the world, innovations in the production of ammunitions is threatening the co-existence of different nations. Recently the acclaimed production of chemical weapons for mass destruction is not and cannot be sustainable. Therefore, there must be regulation regarding invention and innovation mostly in science and engineering. In the block diagram of figure 1, COREN in Nigeria and other regulating bodies in other countries should be able to provide regulation in the practice of engineering. The model in figure 1, is a proposed model for the training of the 21st engineer, this is also illustrated in table 1. The following abbreviations are applicable:

FG	Federal Government
NUC	National University Commission
UFE	University's Faculty of Engineering
COREN	Council for the Regulation of Engineering in Nigeria
NSE	Nigeria Society of Engineers
CB	Corporate Bodies/Organizations
IC	International Collaboration or/and (Citizens in Diaspora)
CEIP	Centre for Engineering Innovation and Prototyping

The Federal Government funds the University, while University programs are regulated by NUC. COREN regulate the practice of engineering and NSE is the professional body whose interest is the well-being of engineers in the country. With good public relations, the UFE can receive financial assistance from CB, IC, CEIP. The research centers are there to further increase research activities. These research centers could be independent or sited in the University as either COREN or NSE centre of excellence. This if adopted would improve research activity and equip the engineer for sustainable innovation.

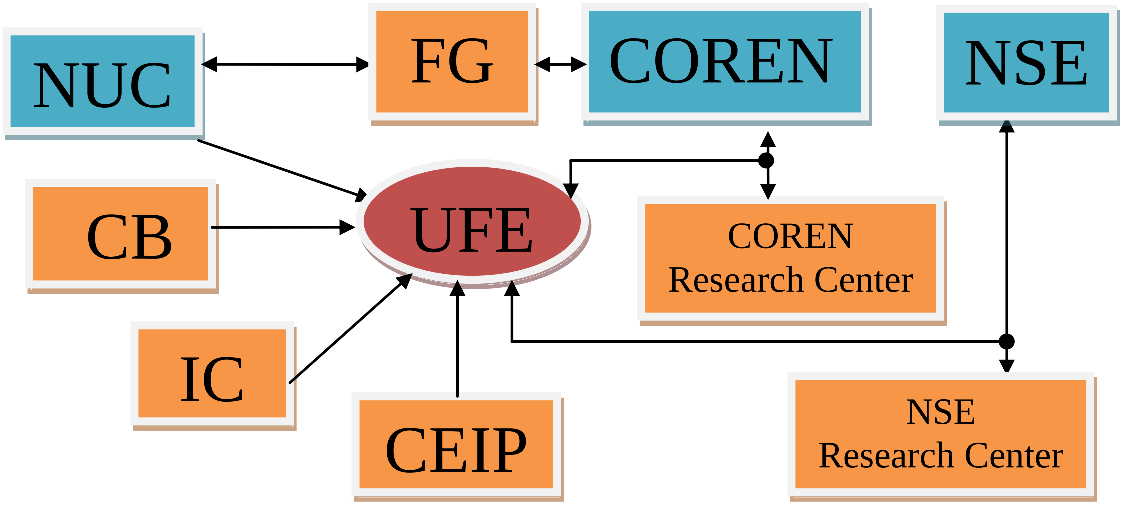


Figure 1: Strategic plan model for engineering education and research

Table 1: Strategic Plan to Remedy the Rot in Engineering Education

BODY	**STRATEGIC PLAN**	**AIM**	**ACTIVITY**	**LOCATION**
FG	12 Universities	To set a benchmark (center for excellence)	Building of lecture theatres, Studios lecturers offices	Two Universities in each of the six geo-political zones
COREN	12 Universities	To set a benchmark (center for excellence)	Setting up Laboratories with modern equipment	Two Universities in each of the six geo-political zones
NSE	Six research institutes	To set a benchmark (center for excellence)	Setting up Research institutes for practice of pupil engineers	One research institute in each of the six geo-political zones
Corporate Bodies and international agencies	Creating centers of excellence	Using the University environment to train their staff	To support teaching and learning of engineering	In any other University within the catchment area

4 Millennium challenges and the global Engineer

Continued technical and professional education is very essential in preparing and updating future engineers to meet the challenges of the millennium goals [9]. In order to globalize the Nigerian engineer to be able to face the global and millennium challenges, the engineer must be equipped with millennium skills. Globalizing the engineer is to equip the engineer with skills and technical know-how for innovation that goes beyond borderlines. Nations strive to compete and participate in the global economy; the engineering profession is the facilitator of global competition. But, the question is; does the engineer posses the skills to face these global challenges? The engineering profession creates wealth. And creation of wealth is related to a nation's ability to make products that other nations will want to purchase. This is where innovation comes in, in order to satisfy the end-user according to a U.S National Academy of engineers as reported in [2, 8], two premises were confirmed as follows;

- *'Global competition – that is imports, exports, cross border investments and international joint ventures – is expanding at a rapid rate. U.S firms can no longer be content with besting domestic competitors; their fiercest rivals now are often foreign firms.*
- *In many markets, the basis for competition today includes not only the price at which the product is sold but the ingenuity, variety and speed of development of new goods and services.'*

Innovation and sustainability are some of the global challenges the millennium engineer is faced with, therefore, stakeholders in this noble profession must note that the competition is a global one. Knowledge and know-how determine how well-off societies are compared to other societies. Education of engineers is critical to every nation to ensure the prosperity of their citizens. Standards of living hinge on our ability to educate a large number of sufficiently innovative engineers [9, 10]. R&D spending fuels innovation.

5 Engineering for Poverty alleviation

Poverty may be defined as human condition characterized by sustained or chronic deprivation of the resources, capabilities, choices, security and power necessary for the enjoyment of an adequate standard of living and other civil, cultural, economic, political and social rights. Here, engineering and innovation is seen as a vital instrument for the overall national goal of reducing poverty and hunger. Poverty is mainly a reflection of the limited access of the people to knowledge and resources with which to address basic relative needs. This knowledge is made available by engineers [11]. The engineering aspects of; water supply, sanitation, housing, food production, energy, transport, communication, income generation and job creation help to improve service delivery. These needs relate particularly to engineering innovation which is vital in this process. Enhancing the access of people living in poverty to knowledge and resources in engineering, science and technology, through innovation and capacity building at the formal and informal level is a necessary step to poverty reduction.

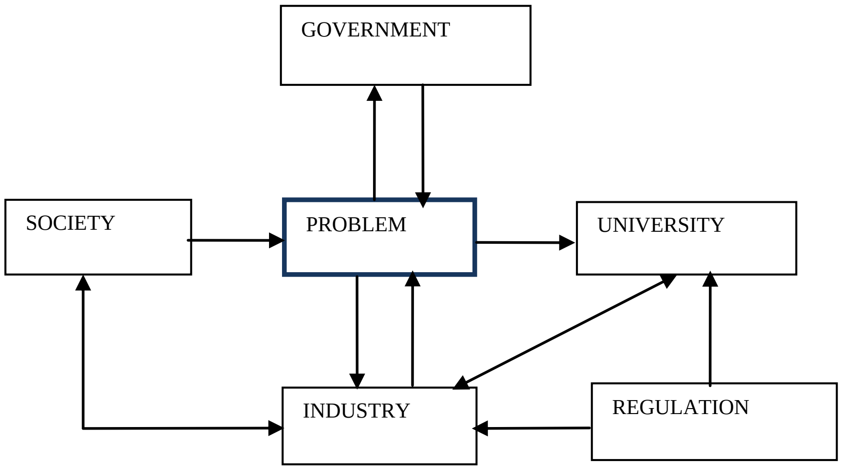
6 Collective responsibilities to solution formulation through sustainable innovation

Engineering programs in the Universities must lay emphasis on solution formulation to societal problems, introducing new dynamics in the solution of problems affecting the well-being and economic growth of the Nation. Rather than putting emphasis on the usual disciplinary division among the different engineering professions, the focus must now be on the main problem areas falling within the jurisdiction of the engineer. Engineering education must place greater emphasis on problem definition and formulation [7]. In figure 2, a block diagram showing the collective responsibility of the University, Industry, and Government is presented. It is a known fact that the engineer is integrated into the society after graduation to contribute to the socio-economic development of the society [8]. The engineer's contribution is a direct function of;

a) The type of training received.
b) The type of engineering infrastructure at his disposal
c) The opportunities that are available to him
d) The love for his society
e) The desire to influence, change, and bring about sustainable innovation

Therefore, according to Charles [9], engineering is dynamic. A lot of changes have been witnessed in technology, it is therefore not proper to educate the 21st century engineer with the 19th century technology. The industry must contribute their quarter through the instrument of industrial training and attachment, Industrial/University resource exchange, project and research funding, etc.

Figure 2: Societal problems: Solution formulation through research



The diagram of figure 2, illustrates the use of innovation for solution formulation. A problem is identified and Government or establishment sponsors a research or floats a research grant that will motivate many researchers from research institutions (University) to proffer solutions to the problem. This innovation must be regulated for sustainability.

7 Conclusion

Engineering profession is the engine room for socio-economic development. The engineer who proffers solution to societal problems must be equipped to the standard of being able to compete globally. Engineering must be seen as a noble profession that brings about invention and sustainable innovation for global competitiveness. If production is of goods and services increased to meet the demand of a growing population of the country, then the Nigerian economy will grow to meet and sustain the comfortability of Nigerians. At the global market, Nigeria will compete favorably with other nations, and then, vision 2020 would have been realized.

8 Recommendations

Having investigated the engineering profession for sustainable innovation, the following suggestion are made and therefore recommended;

- There should be legislation regarding University/Industrial partnership
- Industries should be encouraged to float and fund research work, mostly the ones with high percentage local content.
- Government can also float and fund research work in the University in order to solve the nation's problems.
- Universities should be involved in sustainable innovation by their programs.
- Every University in the country should run entrepreneurship programs and courses for her students; this will go a long way to reduce unemployment.
- Engineering education programs should be updated to depict a proof of technological skills by engineering graduates.
- Final year engineering projects should be chosen based on solution formulation to societal problems.

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Presenter: This paper is presented by Eko James Akpama

EDT Other

Utilization of Technology in Enhancing the Teaching and Learning of Engineering Subjects at Howard University

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Abstract

Like most engineering departments in the United States and globally, the Department of Mechanical Engineering at Howard University has been engaged in continuous improvement of its curriculum over the last decades partly in meeting accreditation standards. Additionally, the faculty members of the department have been engaged in revising the curriculum to increase retention levels of students and to also meet requirements of potential employers of students in the automotive and other major industries. In response to such internal and external influences, the department has vertically integrated technology utilization in the curriculum to enhance the learning of engineering concepts and to better prepare students for the work environment upon graduation.

Beginning with a historical perspective of the mechanical engineering curriculum, the paper describes various initiatives to achieve the goals and objectives as stated for accreditation purposes. Since the receipt of a major in-kind donation from the Partners for the Advancement of Collaborative Engineering Education (PACE) in 2004, the department has made progress in integrating the industrial level suite of engineering software tools that are provided by the PACE organization. Following a description of the PACE award, the paper presents the mechanical engineering curriculum and a description of the enhancements to the various appropriate courses. Particular emphasis is placed on the first year program as well as the final year program in which the students are expected to complete a year-long exercise in solving a problem posed by an industrial partner as well as participating in an optional global course involving four other universities around the globe. The use of the suite of PACE software and other peripherals in outreach programs to excite middle and high school students to opt for STEM disciplines in college is also described in the paper. Numerous examples of students' work in the enrichment process are presented in the paper. The paper concludes with an evaluation of the curriculum enhancements and presents proposals for further improvement.

Keywords: *Technology, Software, Curriculum.*

1. Introduction

In the current digital age and the role of computers in the future, it is essential that engineers of all disciplines have a good understanding and working knowledge of the fundamentals of digital systems as well as fluency in using contemporary computer systems and tools. In addition to strong analytical skills, the engineer must possess the ability to exploit computing and simulation technologies in the modelling and creation of new engineering products [1]. The computer based design-build engineering process, such as was done with the Boeing 777 [2], will become the norm for most product designs, thereby accelerating the creation of complex products for which multiple subsystems combine to form a final product. As part of the design process, there are a number of companies that provide software tools that allow for the creation of a model, meshing the model, and performing finite element analysis on the model to ensure that it meets the design criteria. Software technology exists today for use in the analysis and design of single as well as multi-physics problems in which fluid flow and heat transfer may be coupled to structural interactions.

In addition to software technology for the design and analysis of engineering systems, the use of software for the complete life cycle of a product from the "cradle to the grave" is on the rise in most multi-national corporations such as General Motors and Proctor and Gamble. A number of publications, such as Grieves [3], have been written on the process of "managing" the lifecycle of a product which takes advantage of the internet for use in sharing data among designers and product managers across different continents in different time zones. To keep up with industry practices and to better prepare students for the global environment that has become very competitive, students must be introduced to be able to use the various technology tools that will keep them "ahead of the curve" for them to gain meaningful employment and be productive in any working environment. It is for this reason and others (both internal and external) that the curricula of engineering departments must be dynamic in which changes are made continuously in order to satisfy industry, accreditation and other requirements. The mechanical engineering department at Howard University is no exception and over the years, the faculty have worked assiduously to include internal and external factors in the design and delivery of its curriculum.

This paper describes the efforts of the faculty, external partners and other stakeholders in the continuous design and implementation of the mechanical engineering curriculum at Howard University. The emphasis of the paper is the use of technology in enhancing the delivery and learning of instructional materials with the goal of better preparing students to function effectively and productively upon graduation from the program. Beginning with a historical perspective of the mechanical engineering curriculum, the paper describes various initiatives to achieve the goals and objectives as stated for accreditation purposes. Since the receipt of a major in-kind donation from the Partners for the Advancement of Collaborative Engineering Education (PACE) in 2004, the department has made progress in integrating the industrial level suite of engineering software tools that are provided by the PACE organization. Following a description of the PACE award, the paper presents the mechanical engineering curriculum and a description of the enhancements to the various appropriate courses. Particular emphasis is placed on the first year program as well as the final year program in which the students are expected to complete a year-long exercise in solving a problem posed by an industrial partner as well as participating in an optional global course involving four other universities around the globe. The use of the suite of PACE software and other peripherals in outreach programs to excite middle and high school students to opt for STEM disciplines in college is also described in the paper. Numerous examples of students' work in the enrichment process are presented in the paper. The paper concludes with an evaluation of the curriculum enhancements and presents proposals for further improvement.

2. Technology Infrastructure

A modern and current mechanical engineering curriculum requires that both faculty and students have access to the technology in order to implement computer assisted design and analysis processes to enhance teaching and learning. In generic terms these tools and processes are labelled as Computer Aided Design (CAD), Computer Aided Engineering (CAE), Computer Aided Manufacturing (CAM), and Product Data Management (PDM).

In October 2004, following an introductory qualifying period, Howard University officially became a member of the organization known as Partners for the Advancement of Collaborative Engineering Education (PACE). PACE links General Motors (GM), Autodesk, Hewlett Packard (HP), Oracle, Siemens PLM Software, and their global operations, in the support of strategically selected academic institutions worldwide, to develop primarily the *automotive product lifecycle management* (PLM) team of the future. PLM, as it relates to PACE, is an integrated, parametric-based approach to all aspects of a product's life-from its design inception, through its manufacture, marketing, distribution and maintenance, and finally into recycling and disposal [4]. Currently, PACE is focused on:

- Requirements and planning (concept development)
- Styling (conceptualization and product design)

- Product engineering (vehicle and powertrain detailed engineering design)
- Simulation (validation, optimization)
- Manufacturing engineering (tooling, machining, 3D plant layout)
- Managed development environment (product data management, supply chain collaboration, digital collaboration)

As a member of PACE, Howard University received donations of computer hardware, accessories and industry level software valued at over seventy million dollars. The suite of software included NX (formerly Unigraphics) FLUENT, software from MSC including NASTRAN, DYNA, software from Altair HyperWorks, Autodesk software, Alias and others. Based on the needs of the automobile industry, the two departments that are the primary beneficiaries of the software are the mechanical engineering and the art departments. As a result, the university has two PACE laboratories on campus that contain the hardware and software dedicated for PACE activities and for instructional activities in the execution of the curricula of the two departments. Beyond the initial award of hardware and software in 2004, PACE makes available on a competitive basis additional hardware to its partner institutions on a yearly basis. Through these yearly offers, Howard University has received additional hardware and monetary awards for the development of courseware and for the purchase of equipment for communication among other universities globally.

3. Utilization of PACE Software

The mechanical engineering curriculum is structured so that in addition to learning the basic engineering and science courses, students are exposed to engineering design vertically across the curriculum from the first to the final year. In the first year the mechanical engineering students are expected to enrol in Engineering Graphics (currently called Introduction to Computer Aided Design) and as revised, the students will also take the new course, Introduction to Mechanical Engineering in the second semester. These are in addition to the course, Introduction to Engineering, that is required to be taken by all entering (freshmen) engineering students. In the second year, the students are expected to take the course, Introduction to Engineering Computations, with the potential to apply the knowledge gained in solving problems in courses such as Statics and Dynamics. In the third year the primary courses in which the PACE software are used include the two semester courses, Mechanical Design I and II; and in the final year students execute industry-level design projects in which there are heavy uses of the suite of software. Elective courses such as Product Data Management also require students to use the PLM software from Siemens as part of the PACE award to the university. Descriptions of some of the courses involved with student examples are provided in the next few sections of the paper.

3.1. Engineering Graphics

The first offering of an Engineering Graphics course dedicated to instruction in a particular computer aided design (CAD) software came online in the fall of 2012. Sixteen students, half of the incoming Freshman Mechanical Engineering class for the 2012-2013 academic year, were introduced to the PACE CAD software, Siemens NX. The other half of the incoming class were kept on the "traditional" Engineering Graphics curriculum. The traditional curriculum did not provide CAD software instruction, though students were not prevented from using it for their final projects. This pilot approach allowed for the assessment of the effectiveness of the new approach to teaching the course before expanding it to the entire incoming freshman class the following year.

One significant benefit to this new paradigm in the course-offering, in which the student is introduced to computer aided design (CAD), is the fact that it lasts an entire semester. This allows for a more in-depth look at the computer aided design (CAD) software, NX. Shorter periods of NX introductory lessons offered within the mechanical engineering department only provide an introduction to basic features of the software, namely, sketching, extruding, drafting, assembly and rendering. The semester-long version offers more detailed and complex iterations of the same features. This is with the intention of allowing students to spend more time in learning the software and for each student to find more unique ways to apply its features. The students work on more complex assemblies such as an Arbor Press Assembly exercise found in Leu [5]. It was used as the follow-up exercise to the basic pipe bracket assembly designed to introduce students to the NX software. This was due to its larger quantity of components, which offered the opportunity to use more types of assembly constraints. The length of the course also allowed for the opportunity to mesh the traditional concepts from the previous iterations of the course with the modern software in the current iteration. Concepts such as orthographic views, proper dimensioning methods, and sectioning are still important, especially with the availability and use of CAD software. The method by which a drawing or model is produced does not limit the importance with which it is communicated. Figure 1 depicts a sectioned draft of an airplane engine produced by a student in the course.

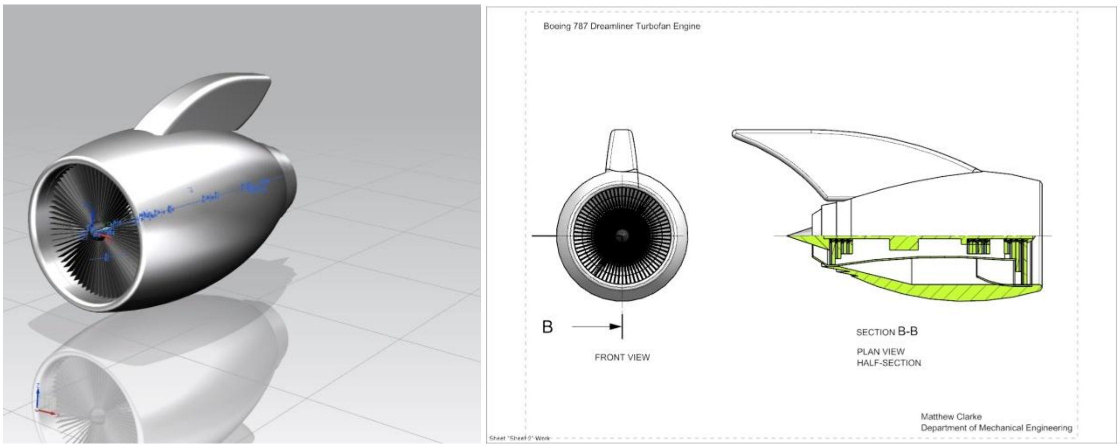


Figure 1 - Student-drawn model (left) and section (right) of an airplane engine model

In addition to an extended introduction to the basics of NX, it is hoped that in future iterations of this course, students will also be provided with modules that expose them to more advanced features of the software such as: human modeling, surfacing, sheet metal design, motion simulation and design simulation. These features were not taught as primary objectives of the revised course, but some elements were explored with students within the course who were progressing at a faster rate than the course intended. Figure 2 on the left shows a student's extra-curricular project of an axle assembly for a radio-controlled car. The completed assembly was then simulated to produce motion. On the right is a student's class assignment, where he designed a steering wheel. The steering wheel model was used in tandem with a seat model to introduce the student to the human modeling feature in NX.

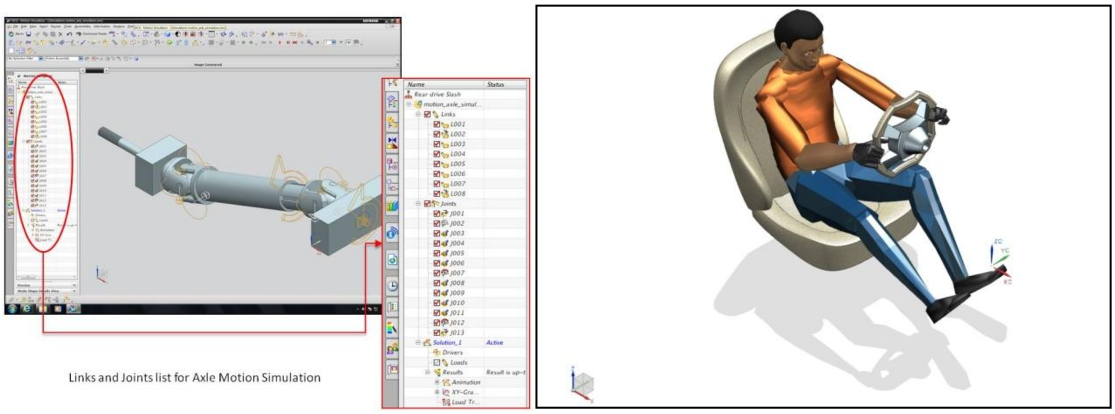


Figure 2 – Motion simulation exercise (left) and human modeling exercise (right)

The intent of this course is to equip students with the ability to thoroughly understand, and effectively communicate their ideas through, engineering drawings. This course represents a means of marrying the concepts of the previous traditional method of teaching engineering graphics with modern computer aided design (CAD) software.

3.2. Mechanical Design

The first introduction of Rapid Prototyping to the classroom environment within the mechanical engineering department came during the fall of 2009, through the Mechanical Design course. For this introduction, the learning outcome was clear. In previous offerings of course, students focused only on the design deliverables that could be quantified, i.e. yield strength, fatigue, and factor of safety. The use of the 3-D printer offered participating students the opportunity to produce physical designs. The availability of this technology gave students the opportunity to see the functionality, practicality and aesthetic beauty of their designs. It also provided students with an idea of the cost of manufacturing their designs by considering the amount of material and time spent in producing their parts in the 3-D printer. The project of choice was to design a purse holder for an automobile. The design constraints were as follows: it must be able to support a purse of about seven pounds, and the purse's contents must be easily accessible from the driver's seat. Additional factors taken into account were: the time taken for the printer to produce each design and the amount of material required to produce each design.

To prepare students to complete this project, they were guided through the basic introductory NX tutorial that required them to draw and assemble the components of a pipe bracket. With the help of a tutorial [4], students were guided through performing a basic structural analysis using the Design Simulation feature of NX, and the NX Nastran add-on to NX. The students completed an NX Nastran tutorial of an impeller as found in the tutorial [4].

Students in the mechanical design course worked in teams to produce and analyze final designs. Figure 3 displays a student team design and corresponding analysis for that design. Final designs were then exported from NX as stereo lithography files, which were imported into the 3-D printer software, CatalystEX, from which the models were printed. On assessment of the parts designed, all models were able to address the weight requirement. They were also all able to provide purse access from the driver's seat, since they were all designed to fit around the passenger seat headrest. The delineation between models came in the categories of print time and material usage.

Table **1** displays the results for the models shown.

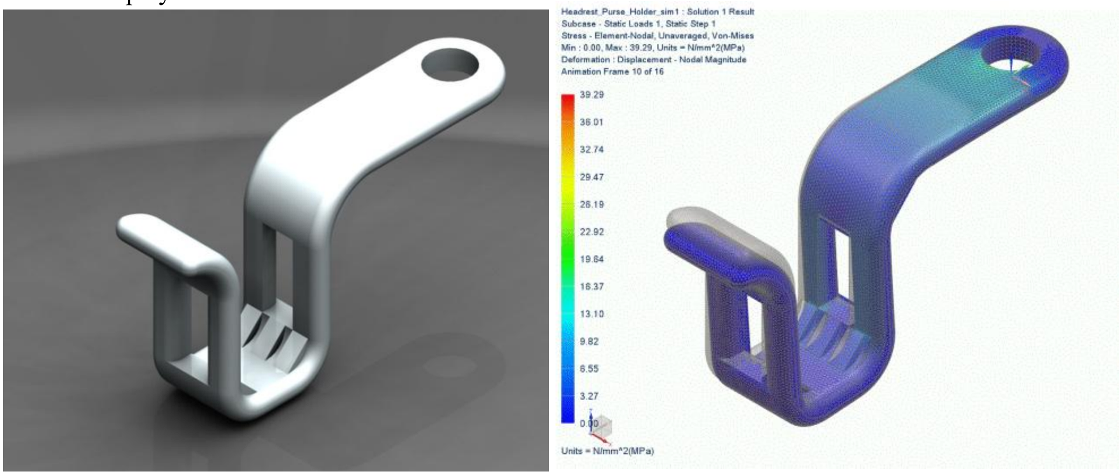
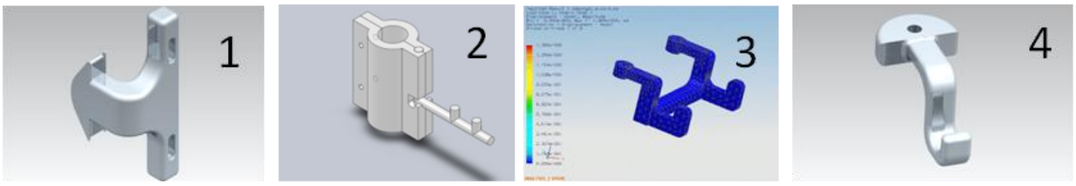


Figure 3 - Model and analysis of a purse holder design

Table 1 - Results for time and material usage by each team (pictures from left)

Team	Time (min)	Primary Material (in^3)	Secondary Material (in^3)
1	607	11.99	2.63
2	143	1.98	0.47
3	1838	43.78	7.2
4	304	6.4	1.15



3.3. Senior Project and PDM

To infuse global awareness into the engineering curriculum at Howard University, students have the option to take a global course that is offered as a technical elective. The notion for the course was conceived when Howard University became a PACE member in 2004. With the encouragement of colleagues at Virginia Tech, Howard joined a team of other PACE institutions in creating a technical elective global course on Product Data Management. This global course is taught among five universities in four countries: Virginia Tech and Howard University in the US; ITESM, Monterrey in Mexico; Shanghai Jiao Tong University, China; and Technische Universität Darmstadt in Germany. The course is taught by video conferencing and extensive use of Internet resources such as Skype for communication by students working in teams on assigned design projects. To take advantage of cultural diversity in enhancing learning and effective teamwork, each student team is formed with students from each of the countries represented in the course. Most of the PLM technology needs to connect all the five universities are provided and managed by the Virginia Tech CAD Laboratory.

Although the capstone design course, Senior Project, at Howard is not designed as a global course, some of the assigned design projects are designed by companies that work in different parts of the world. Until the recent economic downturn, the department of mechanical engineering at Howard had a partnership with General Motors and students were assigned automotive design projects in which they had to take global perspectives in proposing solutions that meet social, political, environmental and geographic constraints. Results from such projects have been prepared and presented by student representatives at international conferences [7, 8].

3.4. Collaboration and Innovation Challenge

One aspect of the use of technology to improve the mechanical engineering curriculum came in the summer of 2013, when Howard University was awarded first place in the Collaboration & Innovation Challenge (CIC) at the PACE forum. Members of the department of mechanical engineering, in collaboration with members of the department of Art sought to tackle the traffic problem in Washington, DC. The solution proposed involved the use of computer aided design (CAD) software to design a pod car dispensation system to work in-sync with the Metrorail system to encourage more commuters to consider public transportation. Figure 4 displays a rendering and draft of the pod car designed in CAD software NX 8.5.

The CAD software NX was also used to design the dispensing system for the pod car. The initial system was designed for dispensing large volumes of cars and it resulted in a large footprint in terms of space. With this in mind, an alternative design was created to take advantage of the pod car’s small size, and already existing parking spaces. This would allow for the injection of dispensation systems into crowded downtown, as well as more suburban locations. Figure 5 (left) shows a rendering of the initial pod dispensation design. Figure 5 (right) shows a rendering of the alternative pod dispensation system.

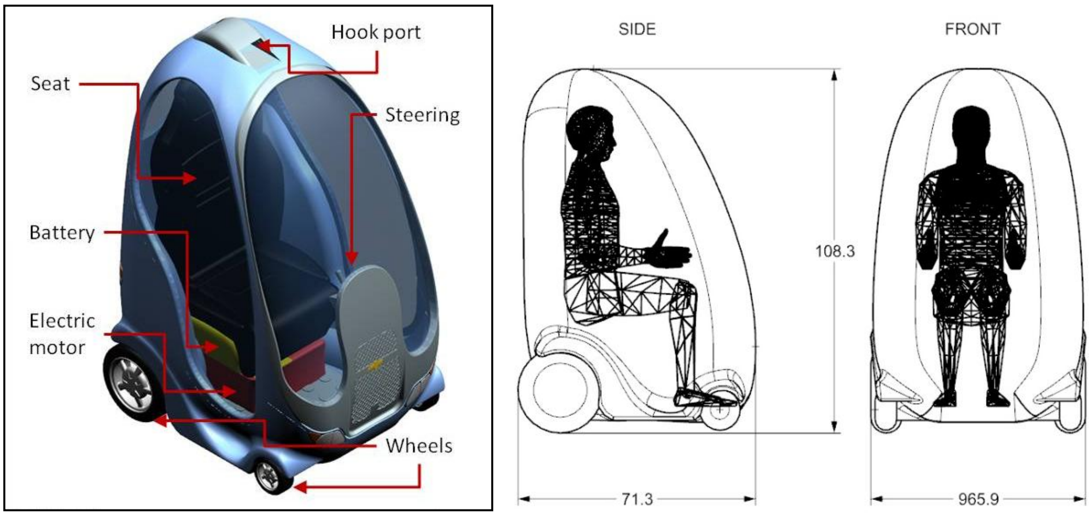


Figure 4 - Pod car design

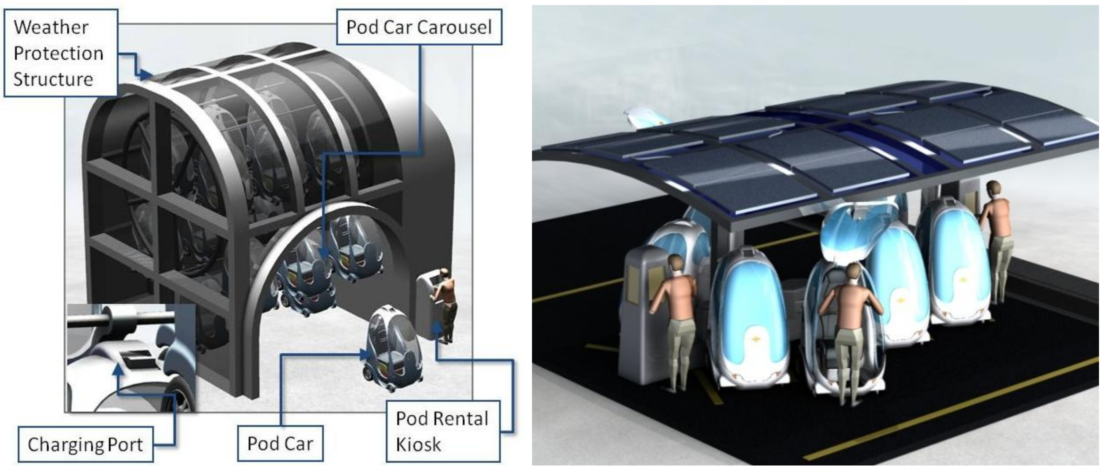


Figure 5 - Initial pod dispensation system design (left), alternative pod dispensation system design (right)

3.5. Outreach Activity

Lessons learnt and experience gained from previous outreach programs were used to develop a two-week curriculum for a high school summer camp that focused on the design process, its applications, and how technology can be used to facilitate them. Also included in the program were lesson plans tailored to helping students with the effective creation and delivery of technical presentations. It was felt that this inclusion, when combined with computer aided design will truly make for well-rounded communicators. The camp also included physical tours of manual and automated facilities within the department's machine shop and fabrication laboratory in the engineering building. Figure 6 show images of the students on their tour of the machine shop. As with the previous iterations of STEM initiatives, the computer aided design software NX was used as the tool through which students were introduced to engineering technology. As a result, the training materials and methods did not vary from what was applied in previous camp settings, and the base for this camp was the department's mechanical design laboratory. To generate interest among students and variety in their solutions, the final projects following the training sessions were different for each team.

Figure 6 - Students with Mr. Tally in the machine shop observing a lathe

The student teams were given their choice of final projects. The three chosen were the design of a device to keep shoelaces from untying, the design of a device to hold a soda can like a mug and the design of a device that can keep a cup from spilling while a plane is experiencing turbulence. As before, students were encouraged to come up with their own designs before meeting as teams to brainstorm on a final design. Figure 7 (left) shows a student team in the process of brainstorming for design concepts. Upon creating a final design, the student teams went about the process of modeling their design in NX with the aid of a mentor. Figure 7 (right) shows a mentor aiding a student team with modeling their final design. Figure 8 (left) shows a rendering of a student team's final design. Following this, the models were then produced in the 3-D printer. Figure 8 (right) shows a prototype of a student team's final design of a soda can holder.

Figure 7 – Student team brainstorming (left), student team working on design with the aid of a mentor (right)

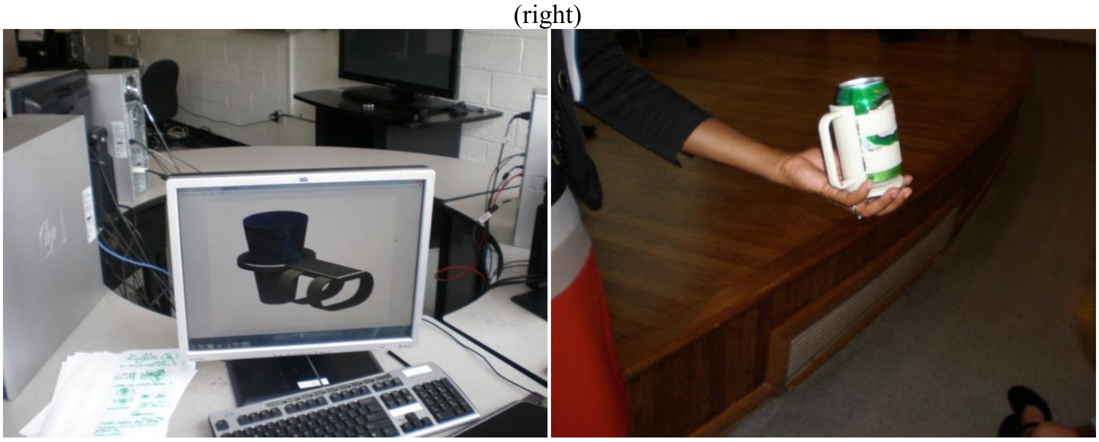


Figure 8 - Rendering of a student team's final design (left) Final student team design for soda can holder (right)

The student teams had an additional deliverable in that they had to deliver a final presentation detailing the design process for their respective devices. Figure 9 (left) shows a student team making their final presentation on the stage in the auditorium of the engineering building. In addition, they also displayed their presentations on poster boards. Figure 9 (right) shows one of the student teams' poster board of their final design for the airplane cup holder. This additional deliverable assessed the students' abilities to not only communicate their ideas through drawings and models, but also their ability to articulate their ideas and present them in a way that makes it meaningful and understandable to an audience.

Figure 9 – Students making final presentation (left), a student team's poster board (right)

4. Evaluation and Assessment

The effectiveness of any academic curriculum is determined by the quality of the students graduating from the program as determined by external stakeholders such as employers. Although the changes made in the curriculum are recent changes it is clear that students have embraced the new paradigm of teaching some of the courses and are taking more interest in using the technology resources to explore the engineering of new products. As an example, Matthew Clarke, a first-year (freshman) student who participated in the new paradigm of teaching Engineering Graphics, successfully passed the Siemens NX certification exam for the 8.5 version of the software. This was the version of the software used in the course in the last fall semester. His success in passing the exam on his first try lends credibility to the content of the curriculum, and the method of imparting this content to students. A graduate student, Mr. Atiba Brereton also passed the exam on first try and earned an NX 8.5 certificate. Both students received the certificates during the closing banquet of the 2013 PACE annual forum in Pasadena, California. Additionally, the university was also awarded a silver certification by PACE based on annual reports submitted in the last three years. The university is one of only 11 US PACE institutions to receive such an award.

5. Summary and Conclusions

The paper has described an effort of the faculty of mechanical engineering at Howard University to infuse technology usage into the curriculum to enhance teaching and learning. The technology resources are based mostly on in-kind award of software and hardware received from the PACE organization in 2004. Although revisions in the curriculum have been made on a continuous basis, it appears that the current curriculum will be effective in achieving the goals of the department and to also meet requirements of external stakeholders.

In spite of the early success of progress in meeting departmental goals, there is room for introducing engineering software into other classes to assist students in learning engineering fundamental concepts. Undergraduate courses such as Statics, Dynamics, Fluid Mechanics and Heat Transfer are candidate courses in which students can benefit from the utilization of software to enhance their understanding of complex scientific principles. Extended outreach activities involving middle and high school students in the use of the PACE software have been conducted and additional results of the enrichment exercises will be reported in a future paper.

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Co-author: Atiba Brereton is a graduate student in the mechanical engineering department having just completed requirements for the master's degree. He is a certified Siemens NX 8.5 user and has interests in design and manufacturing. He assists Prof. Warner in teaching the design course in the curriculum.

Presenter: This paper is presented by Emmanuel Glakpe

The Study of Various Additives of Carbon Fabric/Phenolic Composites and Its Effects on the Mechanical, Thermal and Abrasive Characteristics with Autoclave Method

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Abstract

Carbon/phenolic composites are used in the nozzle parts of solid rocket motors due to their heat-resisting, ablation, and high strength characteristics, which are required to endure the high temperature and pressure of combustion gas passing through the nozzle. One of the most important factors on erosion rate is the void content of the ablative composites. Facilities should be designed to simplify the exhaust of volatile components, in order to reducing the void content in the manufactured samples. Accordingly, to reduce the void percentage of carbon/phenolic composites in this study, samples are manufactured by the vacuum bag molding technique, and they are cured in an autoclave. In order to compare of the effect of manufacturing process on the ablation characteristic of carbon/phenolic composites, another batch of samples has been produced by the acid curing method. According to ASTM E 285-80, they are exposed to a plasma torch flame. The results show that the void percentage of samples which are manufactured by the autoclave process is 60% lower than the acid-cured samples, and this leads to reduce the linear erosion rate of these composites.

Keywords: *carbon/phenolic composites, ablation, autoclave, acid curing, plasma torch*

1. Introduction

During atmospheric re-entry, ballistics or space vehicles are subjected to severe aerodynamic heating and their successful return through the Earth's atmosphere depends largely on the provision that is made for reducing aerodynamic heat transfer to their structure. For this purpose an ablative heat shield is normally used which undergoes physical, chemical, and mostly endothermal transformations. These transformations produce new liquid or gas phases which are subsequently injected into the environment [1].

Ablation is an effective and reliable method largely used in aerospace structures to protect the payload from the damaging effects of external high temperatures. In the ablation process, the high heat fluxes are dissipated by the material through a series of endothermic processes. That finally leads to the loss and the consumption of the material itself. The working process of an ablative heat shield as shown in figure 1 can be briefly summarized as follows; the convective heat that reaches to the vehicle surface is balanced by surface radiation, phase transitions, and chemical reactions. Moreover, part of the incoming convective heat flux is blocked by the outcoming flow of hot gases that result from the degradative processes. The ablative material keeps the surface temperature within a certain range and as a consequence an increase of the heat flux will not cause a consistent temperature raise, but will cause an increase of the surface recession rate [1].

Charring ablators produce char as an effect of the thermal degradation reaction. As the charring ablator is heated, the temperature increases until the surface reaches the degradation temperature and starts to

release gaseous products, leaving a porous carbonaceous residue, i.e. char. Char formation has long been recognized as an effective means of improving the fire retardancy of synthetic polymers [1].
Among the common plastics, the phenolic resins give the highest yield of carbon during pyrolysis, and they have been widely used as surface charring ablative materials. Since the char is relatively weak, and is removed mechanically by high shear forces associated with re-entry, fibers of carbon, silicon dioxide, refractory oxides, mineral asbestos, or even glass have been added to assist the char retention [2].

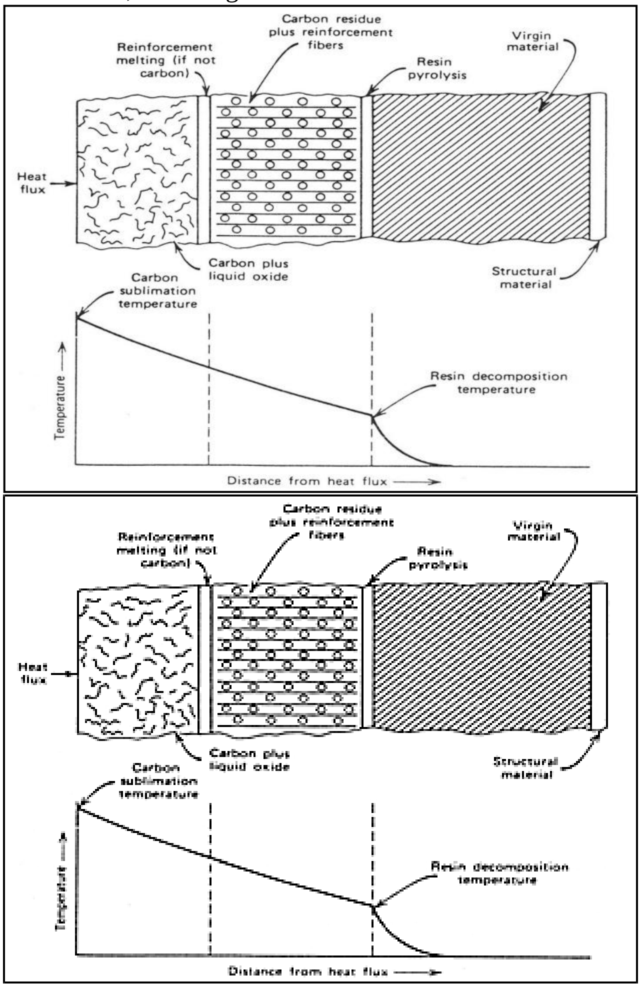

Figure 1. Schematic diagram of the ablation process [2].

For solid rocket motor applications, the key requirements of carbon fiber composite are not only of low thermal conductivity to minimize the thickness of paralyzed carbon layer but also of high interfacial strength to reduce possible catastrophic erosion by abnormal ablation behaviour. Therefore, development of PAN-based carbon fiber composites having comparable thermal conductivity and interfacial strength with rayon-based carbon fiber composites has been in great demand [3]. Additional processes could be done on the constructive materials of these composites or additive material can be used in order to improve the thermal resistance, ablative, interlaminar characteristics and thermal conductivity reduction of these composites [4, 5].

Hence, in this study in order to investigate the effects of additives on interlaminar shear strength, ablative and thermal properties of heat resistant composites, four groups of samples were fabricated in an autoclave by a conventional vacuum bag molding method. The Fiber and resin (Resole and plain carbon fabric (C/P)) ratio of the first set of specimens were adjusted to 50/50 wt%. To investigate the effect of paratoluenesulphonic acid (PTSA) on the resin absorption of carbon fabric and interlaminar shear strength of final composites, a second set of specimens, resol based reinforced composites with carbon fabric embedded in paratuloenesulphonic acid solution along with butyra resin (C/P/PTSA), were investigated on the samples with Polyvinyl butiral resin (PVB), Resole and carbon fabric reinforcement (C/P/PVB). The last set of specimens with Resole, PVB, PTSA and carbon fabric reinforcement (C/P/PVB/PTSA) was produced.

The interlaminar shear strength was studied to evaluate the effect of PVB and PTSA on the attachment strength of reinforcement to matrix and finally it's relation with the ablation characteristics of the composites. In order to explore the interlaminar shear strength of the composites, short-beam shear test was conducted. Also thermal conductivity was measured in transverse directions. To explore the ablative characteristic of the composites in terms of insulation index and erosion rate an arc plasma torch with heat flux of 15 MW/m2 at approximately 2700˚C was used.

2. Experimental Details

2.1. Starting Materials

High-strength PAN-based carbon fabric with (0-90) plain texture (TC33 3K, Tairyfil Co., Taiwan) was used as a reinforcement for carbon/phenolic in this study. The physical properties of the carbon fabric are summarized in Table 1.

Table 1. The physical properties of PAN-based carbon fabric (TC33-3K).

Fiber texture	Areal weight (gr/m^2)	Thickness (mm)	Fiber density (gr/cm^3)	Tensile Strength (MPa)	Tensile Modulus (GPa)
Plain (0-90)	200	0.3	1.80	3790	234

Also Resole-type phenolic resin (IL800, Resitan Co.) was used as the matrix precursor of the composites (Table2). Polyvinyl Butyral resin (PVB) (B30H, Catrin Co.) and p-toluene Sulfonic acid (PTSA) purchased from Aldrich Chemical Co. were used as an additives to the matrix phase.

Table 2. Properties of resole type phenolic resin (Resinan, IL800).

Property	Unit	Value
Density	Gr/cm^3	1.21±0.02
Viscosity of liquid resin at 20˚C	MPa.s	600-800
Solid content	wt%	75±3
Specific heat	J /kg.K	2000
Thermal conductivity	J/ m.K	0.35
Gasification coefficient	-	0.6

2.2. Preparation of Samples

Four groups of carbon/phenolic composites manufactured in this study are defined as below:

a) C/P = Resole matrix composite reinforced with carbon fabric (50-50 wt %)
b) C/P/PVB = Resole matrix composite reinforced with carbon fabric with 20 wt% polyvinyl Butyral resin
c) C/P/PTS = Resole matrix composite reinforced with carbon fabric with 4-6 wt% p-toluene Sulfonic acid.
d) C/P/PVB/PTSA = Resole matrix composite reinforced with carbon fabric with 20 wt% polyvinyl Butyral resin and 4-6 wt% p-toluene Sulfonic acid.

Carbon/phenolic composites were fabricated in an autoclave by a conventional vacuum bag molding method. At the beginning Carbon fabric was cut to desired dimensions (10×10 cm^2) and they were saturated with Resole and then the prepared batch was pre-cured in an oven. Prepreg layers were hand laid up in a metallic mold. In the manufacturing of samples with 4-6 wt% PTSA, because of the presence of water absorption agent (PTSA), the process of the prepregs manufacturing in oven was eliminated.

2.3. Thermal Analysis

Thermal Gravimetric Analysis (TGA) is done on Resole in atmosphere from ambient temperature to 700˚C with 10˚C/min heating rate, to determine the mass reduction of Resole in different temperatures in order to finding the Resole curing cycle, by Ushimatso 50 apparatus.

2.4. Composite Curing

After layer saturation and hand lay-up into the mold the samples are cured in autoclave at 160˚C final temperature with 8.1˚C/min heat rate and 100 psi pressure. Samples will stay 1 hour at final cure temperature (160˚C) and then it will cool down slowly to ambient temperature.

2.5. Thermal Conductivity

The thermal conductivity of the composite laminate through its thickness was measured by employing a LT108 Taurus TCA 200 apparatus. Measurements are conducted in ambient temperature.

2.6. Density Measurement

After the manufacturing of samples, their density is measured according to ASTM D 1505 [6]. This test method covers the determination of the density of solid plastics and test method is based on observing the level to which a test specimen sinks in a liquid column exhibiting a density gradient, in comparison with standards of known density. This test method is designed to yield results accurate to better than 0.05 %.

2.7. Ablation Test

According to ASTM E 285-80 [7], a plasma torch test was performed to investigate the ablation property for carbon/phenolic and other three different types of composites. This test method covers the screening of ablative materials to determine the relative thermal insulation effectiveness when tested as a flat panel and also the surface erosion when tested as a cylindrical element in an environment of a steady flow of hot gas provided by a burner. Figure 2 shows the oxyacetylene flame test apparatus.

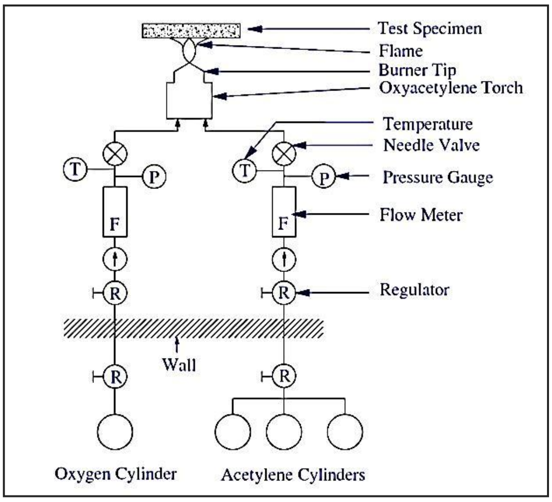

Figure 2. Standard oxyacetylene flame test apparatus [7].

During the ablation test, each specimen of a plate form with 100 mm×100 mm size was exposed to the flame composed of argon. A Chromel-Alumel thermocouple was firmly attached with phenolic resin at the centre of the back faces of a specimen in order to record the temperature variations as a function of time during the ablation test. The distance and the angle between the front surface of the specimen and the nozzle tip of a plasma gun were 40 mm and 90˚, respectively. The flame was of high velocity and pressure at about 2700˚C and 15MW/m2 heat flux. The specimen was placed vertically to the flame direction in air by the designed fixture. The burn-through time was measured. The erosion rate was calculated by dividing the specimen thickness or the weight change before and after the test into a burn-through time for each specimen. The average value was taken from the result after repeating the test with several specimens. The erosion rate according to equation 1 was calculated by dividing the specimen thickness before and after the test by a burn through time for each specimen.

$$E = d / b \quad (1)$$

Where E = erosion rate (m/s), d = thickness of panel (m), and b = burn-through time (s).

The insulation index was obtained from the time reaching the temperature change of 80, 180, and 380°C (from ambient) of the back-face of the specimen divided by the specimen thickness specimen, as follows:

$$I_T = t_T / d \quad (2)$$

Where I_T = insulation index at temperature T (s/m), t_T = time for back-face temperature changes of 80, 180, and 380°C (s), and d = thickness of specimen (m).

This sample during the plasma flame test is shown in Figure 3.

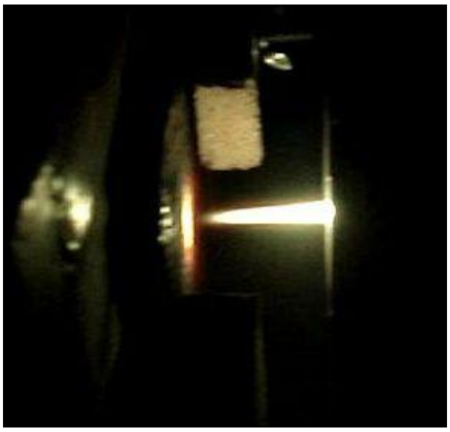

Figure 3. Plasma arc torch during the ablation test.

2.8. Shot-beam Shear Test

In order to explore the interlaminar shear strength of carbon/phenolic composites, short-beam shear tests were conducted using a universal testing machine (Amsler/Zwick 50 ton) according to ASTM D-2344. The specimen is a short beam machined from a flat laminate up to 6.00 mm thick. The beam according to figure 4 is loaded in three-point bending [8]. The crosshead speed was 1.3 mm/min and the span-to-depth ratio was 4. The number of specimens for each measurement was 3. The purpose of this test is to compare the shear strength of composites in this study and finding the relation between ablation characteristics and interlaminar shear strength. Short-Beam Strength can be calculated using Eq 3 as follows:

$$F^{sbs} = 0.75 \times \frac{P_m}{b \times h} \quad (3)$$

Where; F^{sbs} = short-beam strength (MPa), P_m = maximum load observed during the test (N), b = measured specimen width (mm), and h = measured specimen thickness, (mm).

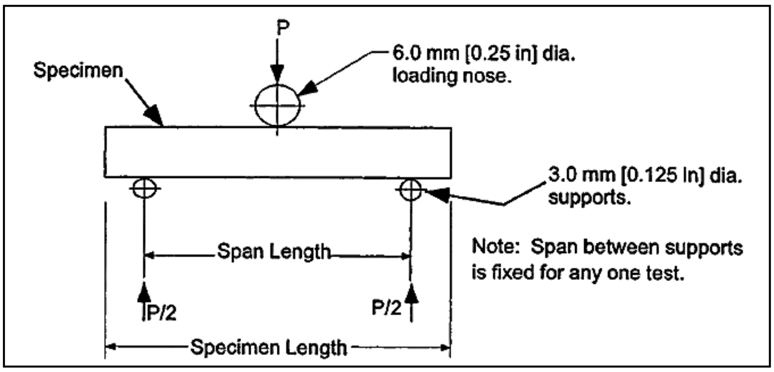

Figure 4. Horizontal Shear Load Diagram (Flat Laminate) [8].

3. Results and Discussion

3.1. Physical and Thermophysical Characteristics

Physical properties of manufactured composite samples are shown in table 3. As may be seen, samples cured with Paratoluene sulphonic acid have more void content percent than other samples. This amount for C/P/PVB/PTSA samples is 59.6 % more than C/P composites. Furthermore among C/P composites, those which are manufactured with autoclave technique have more density and void content percent. The cause of void content in the structure of composites cured with Paratoluene sulphonic acid is the high level of PH in resin and acid mixture that leads to capture of freed water-Formaldehyde vapor in composite, which this vapor itself is a result of exothermic reaction between acid catalyst and methyl-ether meanwhile curing process [9].

Table 3. Physical properties of manufactured composite samples

Characteristics	C/P	C/P/PVB	C/P/PTSA	C/P/PVB /PT SA
Dry weight, g	106.56	115.47	88.67	93.42
Thickness, mm	8.05	9.03	7.70	8.24
Bulk density, g/cm3	1.43	1.30	1.11	1.15
Apparent porosity,%	3.74	5.02	9.10	9.26
Thermal conductivity, W/m.K	0.5930	0.1792	0.2281	0.2540

We can conclude from the figure 5, that void content is in direct relation with linear erosion rate. The cause of higher erosion rate in C/P samples, despite the fact that their void content is lower, is their strong layers connection and in addition to high thermal conductivity that is more improved in PVB containing samples. In addition, adding PTSA does not have a good effect on linear erosion rate because of its remarkable increasing of void content, decreases the weight erosion rate.

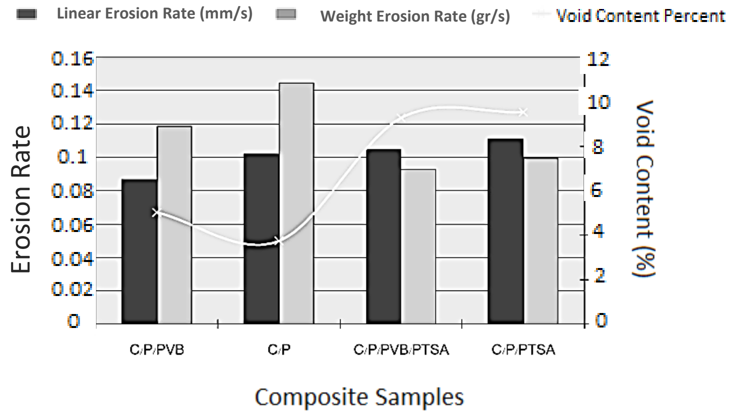

Figure 5. Diagram of void-content percent and linear and weight erosion rate

3.2. Ablation Test Results

Table 4 shows the results of thermal ablation test with plasma torch and oxy-acetylene torch on these four types of composite samples. This table shows the amount of thermal and erosion rate in composite samples with two factors of linear erosion rate (mm/s) and weight erosion rate (gr/s). Linear erosion rate that is obtained by division of sample thickness into passed time until seeing a red hole in the back of sample, is the most important factor in the study of ablative heat sinks.

Table 4. Comparison between two effective factors in erosion resistant of composites

C/P/PVB/PTSA	C/P/PTSA	C/P/PVB	C/P	Composite Type
Erosion Rate in Plasma Torch				
0.1048	0.1108	0.0866	0.1019	(mm/s)
0.0927	0.0994	0.1185	0.1444	(gr/s)
Erosion Rate in Oxyacetylene Torch				
0.1122	0.1251	0.0936	0.1198	(mm/s)
0.2161	0.2094	0.1185	0.1615	(gr/s)

According to table 4 we can conclude that linear and weight erosion rate in resol base composites reinforced with carbon fabric in plasma torch test are respectively 15% and 20% and in oxyacetylene torch test are respectively 16% and 62% lower than that in one-way fiber reinforced composites. From this fact, we conclude that decrease in carbon/phenolic composites mechanical strength, has a remarkable effect on ablation resistance in this type of composite. Table 5 compares the amount of increase and decrease in factors related to tested composites with both torches by percent.

Table 5. Comparison between increase and decrease of the main factors in ablation test of composite samples with plasma and oxyacetylene torch

Weight Erosion Rate Increase Percent From Plasma Torch to Oxyacetylene Torch (gr/s)	Linear Erosion Rate Increase Percent From Plasma Torch to Oxyacetylene Torch (mm/s)	Sample
11%	15%	C/P
0%	7%	C/P/PVB
52%	11%	C/P/PTSA
57%	7%	C/P/PVB/PTSA

According to table 5, we conclude that linear erosion rate for C/P composites under oxyacetylene torch, is 15% more than the value in the plasma test torch. This increase in erosion rate in oxyacetylene torch despite higher thermal flux in plasma torch is a result of two factors:

1. Increased chemical degradation as a result of the oxygen oxidation agent during thermal ablation process
2. 33% higher front distance of nozzle from samples' surface in plasma torch test (30mm) than oxy-acetylene torch test.

4. Conclusion

Three types of carbon/phenolic (CP) composites with PVB and PTSA were fabricated, and their mechanical, thermal and ablative properties were measured. Short-beam shear test indicate that the interlaminar shear strength of the C/P/PVB composite is 17% greater than that of the other samples. Observations show that presence of 20% PVB has an important effect on proper adhesion between carbon fibers and Resole matrix of C/P composites and achieving improved interlaminar characteristics.

The ablation test results reveal that composites with 20% polyvinyl Butyral resin (C/P/PVB) have the highest ablation resistance and the erosion rate (mm/s) of these specimens are 20% lower than the other specimens. Additionally the high insulation index of the C/P/PVB samples indicates that these composites are the best ablative materials in the present study. But results show that the mass reduction percentage of C/P/PTSA/PVB samples is around 28% lower than C/P/PVB samples. Furthermore, addition of PVB to C/P composites caused 70% improvement in the thermal conductivity of C/P/PVB composites. For samples with 4-7 wt% PTSA, against expectations, these samples because of porous structure, did not have appropriate ablative performance.

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Technology Education

Innovations in e-Learning

Innovation in e-learning: Predictions for the future

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Abstract

The recent explosion in the use of the internet and the advances in social media brings into focus the spread of e-learning as a serious education and training tool that needs to be adopted in our learning institutions. Gone are the days when academics and teachers saw this as a means of furthering their own research/teaching or as a mechanism to communicate with their colleagues. New technology especially those that are aligned to e-learning provide an opportunity for institutions of higher learning to overcome some of the challenges facing them. New technology while currently available to millions of youth and learners bring about its own challenges. These challenges are compounded by the world recession and other economic crisis that in no small way affects implementation because of infrastructural and resource deficiencies. Notwithstanding the advances already made in internet technology, the age-old academic questions of relevance, learner capabilities and costs are found to be limiting factors that hinder progress in this area. This paper takes a snapshot of the current state of e learning in some countries across the world and in Africa by reviewing literature on the subject. . The paper concluded by highlighting some of the challenges that need to be addressed in order for e-learning to be a success in the future

Keywords: *Internet, e learning, technology, distance education, virtual university, institutions of higher learning.*

1. Introduction

During early 1980's there was buzz about distance education and how it was going to transform education in the country. The prediction for the future was that the increasing numbers of students entering universities were going to be accommodated by means of offering courses through distance education. The advent of the electronic age made the distance learning concept even more glamorous because the picture created was that of students sitting in front of their computers in the comfort of their homes and obtaining their degrees from the many universities that were going to open up to offering courses through distance learning. The concept was simple, or thought to be, because it was felt that the University of South Africa (UNISA) was already doing part of this, with much success. As the years rolled by this 'glamorous picture' became clearer. The picture of a student in front of his computer at home or a local restaurant now included them interacting with their lecturers and tutors.

Unfortunately, almost 30 years later, the boom that was predicted has not really happened, resulting in more and more students becoming disillusioned with not being able to gain entrance to one of the many universities that are already bursting at the seams because the relief that technology was going to create, never really materialised. Classroom learning is still the South Africa norm. The initial euphoria that technology, especially e-learning was going to enhance tertiary education and lessen the cost thereof has not reached the dizzy heights that it was made out to reach. What about the ability of e-learning revolutionalising the learning environment? Is the use of technology or more specifically e-learning in the tertiary sector on the increase? Have academics used this to enhance the learning environment. Have universities changed the way they teach or for that matter used e-learning to address the challenges that faced learners coming from a poor schooling system? Are there sufficient resources available to promote e learning? These questions continue to plague us. Do we have the answers?

The use of e-learning in education and training to address the challenges of learners coming from an inadequate schooling system, to enhance the learning experience, to promote research and to form networks amongst and between learners and lecturers are areas in this day and age, no longer a choice but a necessity. This article surveys some of the institution overseas and thereafter looks at the experiences of institutions in Africa and South Africa. This article concludes with providing some predictions for the future direction of e learning in South Africa.

2. What is E-learning?

E-learning has been variously described as "… the use of information and communications technology (ICT) to enhance and/or support learning in tertiary education".[1] E-learning is also seen by some authors as the application of electronic technological systems to support the learning process.[2] E-learning comes across as a learning instruction that is delivered through a electronic device including, desk top and/or lap top, or mobile device such as phones, PDA's and electronic storage devices. This includes the storage/ transmission of information through electronic means, provision of content that is learning related, use of media and instructional to deliver information, help learners to acquire new knowledge and skills, which may involve instructor led instruction and/or individual based study.[3]

E learning may be categorise into several different types which include the following: [4]

- web-supplemented – this category provide a dual system of instruction which is essentially classroom based but uses e-learning for course outline, lectures notes and email.
- web dependent – in this category while the classroom time remained relatively unaltered the learners are required to use the internet for discussions, assessment and projects.
- mixed mode – in this category online use increases while there is a gradual decrease in classroom, face to face interaction without completely eliminating classroom time.
- fully online – this category allows for learners to complete their course through distance education without spending time in a class room like the other categories of e-learning. Fully online e-learning allows learners to register for courses in different towns, cities or countries while being located somewhere else

E-learning is a type of online learning that can take place in or outside of a classroom and which includes the use of technology in the form of "electronic media and information and communication technologies". E-learning uses education technology which includes "types of media that deliver text, audio images, animation, and streaming video, and includes technology applications and processes such as audio tape, satellite TV, CD-Rom and computer-based learning, including intranet and extranet.[5] Users of e-learning have characterised e-learning with terms such as: 'flexible and personalised'; 'knowledge enhancing'; 'innovation'; 'integration'; 'practical'; 'forward looking'; 'economic'; 'connectivity' and 'education learning and training'. [6]

The various definitions on the subject have not confined us to any one definition of e-Learning. Broadly speaking e-learning is seen as a tool for learning, that benefits learning in a classroom/lecture room situation. Therefore the use of e-learning needs close attention.

3. E-Learning in Education

Education in its simplest form may be seen as the preparation of students with the skills that would equip them to deal with challenges that they face in their future development. "Education must prepare learners with skills and competencies that enable them to navigate and make well-founded choices in their lives and working careers…".[7]

Information and computer technology, commonly referred to as ICT, is part of our everyday lives with the younger generation being privileged enough to being born in this technological generation. The internet which has become prominent in the last decade has started to dominate our lives in the domain of "electronic services" in the form of e-mailing, e-banking, e-filing, e-payments, etc. With the social media explosion, communication through, Face book, Twitter, Viber, Skype, WhatsApp, and SMSes has dominated the lives of those who are savvy with technology. Children, now equipped with a cell phone and their own or family computer are using them "… for playing games, downloading music, and communicating through social networks".[8] The question that needs to be asked is how much of this use is being transformed into educational usage in the classroom/ lecture room?

The case of University of South Africa (UNISA) demonstrates the power of technology and e-learning. The movement from purely distance learning institutions to a virtual university with over 350000 students demonstrates the power of e-learning which include coping with the increase in the number of students and being able to reach their students moving in different parts of the world. In Universities besides the use of the internet for e-mailing, research, communicating students notes and assignments and using Google to engage in their favourite pastime, academics in most institutions have not set the scene alight in the use of e-learning to enhance the class room learning. In the case of learners besides using their cell phones and the internet for exercising their fingers in social media communication they have not to any to sizable degree used it to enhance their education/ learning.

4. E-Learning in countries around the world

In countries around the world including Hungary, Cyprus, Slovakia, Malta, France, Germany, Estonia, Finland, Northern Ireland, Norway an increase in technological awareness has been noted. Policies have been formulated and money has been set aside to enhance the use of technology in places of learning.[9] The increase in the numbers of computers (including laptops) to match the number of learners are becoming a norm. Quality internet connections for learners and educators are being provided with the aim of increasing their technological skills. Curricula have been amended to incorporate the use of the digital experience in the learning exercise. A component of the educator's training curricula have been amended to increase their media skills. E-learning has become an integral professional development tool. Educators have the opportunity to obtain qualifications in e-learning and are being encouraged to use information and computer technology in their work. [10]

Countries around the world are increasingly exploring ways in which the opportunities created by the new technological development can improve the lives of its citizens including educators and learners. While different countries are making strides in the use of technology and its development in the different spheres of society and learners using this to develop their basic computer and their social networking skills, the shift into the educational institutions, especially in making it an integral component of the learning experience still has some distance to travel.

5. E-Learning in Africa

Africa as a continent has challenges that are in most cases completely different from other economies. The issues of poverty, unemployment, rural underdevelopment, lack of resources like housing, water and electricity are factors that impact on the provision of services that includes access to information technology. Increase in the use of and access to information technology, "… is key to how …children develop educationally." It is predicted that while "information technology like mobile phones…" are used in our everyday lives "… e-learning goals in Africa can only be achieved in future if classroom technology is intrinsically sustainable." Accordingly if e-learning needs to be expanded, authorities "…need to ensure that the classroom technology is self sufficient and simple to setup, manage and use in the classroom." [11]

In Africa, technology especially pertaining to e-learning, has been through the use of "…computers, lap-top, Ipad, the Internet, projectors and mobiles". In the use of computer software and learning programs, the most common use has been of PowerPoint, Moodle, Social Media, VSAT, WIKI, ADOBE, Microsoft, Smart board, Black board, Open source, sms, Google, e-mail, videoconference, e-journals, wireless, e-Book, e-Library, teleconference, Youtube and Skype.[12] In reviewing the contributing factors that hinders the growth of e-learning in countries that included Ghana, Kenya, Nigeria, South Africa, Tanzania Uganda and Zambia financial resources, connectivity (bandwidth), human resource capacity and limitation and cost of electricity in different areas especially semi-urban and rural were common. In establishing the factors that was considered to be most influential in promoting e-learning the following were highlighted by the different countries: access to appropriate content for ICT-enhanced learning and training; infrastructure for ICT-enhanced learning and training: electricity, buildings, broadband; professional development and training for ICT-enhanced learning and training; and access to affordable and reliable computers.[13]

In South Africa while an increase in e-learning since 2003 has been noted, information from respondents have indicated that they are not sure whether e-learning is being used in their organisations. The constraining factors of lack of resources both human and capital, electricity, rural and under resourced schools, directly affect growth in e-learning.[14] The promotion of e-learning in institutions become more of a problem when respondents (employees) have no clue about what is going on in their own institutions. This general apathy is seen as a stumbling block in the advancement of e-learning in institutions.

6. E-learning in South African Universities

The implementation of e-learning has progressed at different rates amongst the South African universities. The success of some of these initiatives has been through institutional policies while other have been through individual efforts. The lack of progress is largely due the lack of institutional policy, management support, unavailability of resources and disinterest by academics and students.

Neil Evans in his letter of motivation to the Senate for the adoption of the e-learning Implementation Strategy and Plan at the University of Zululand pointed out the following: "… although limited e-learning facilities and resources have existed for around a decade at the University of Zululand, the use thereof remains relatively isolated and largely unsupported.[15] Buy in by the majority of lecturers at the University has been slow, and drives launched to promote and train staff to use these resources have failed in the past. One of the stumbling blocks encountered by lecturers included low computer literacy rates despite the fact that most of them have a networked computer with access to the Internet. Students' enthusiasm to use ICT and a low PC to student ratio (1:22 or 600:13000) leads to congested facilities that are one of the threats that inhibit the campus wide roll out of e-learning. However planning for an additional two hundred (200) workstations and good management of existing facilities together with the upgrading of internet bandwidth could ease the present digital divide…".[16] The University has no institutional policy that promotes e-learning in the academic domain. The lack of contribution from leadership and structures to promote technical and system support has been cited as areas that restrict the growth of e-learning. Individuals or interest groups who are technically informed drive the bulk of the e-learning exercise. The lack of promotion of e-learning has been blamed on the lack of funding and resources.[17] The University of Zululand has server resources which are available but while technical assistance is available it is limited. The resources in the computer labs have also been found wanting with approximately 1PC to 17 students. To complicate issues further the times that have been allocated for the use of PC reduces the availability. In addition there are only a limited number of students who own their own PCs. Adding to the concerns at the university is that most academics and students at the University of Zululand will need to be trained in e-learning technology.[18] While the University of Zululand must be recognised as a previously disadvantaged university that faces competing challenges and priorities against which the implementation of e-learning must be evaluated, the lack of an institutional e-learning policy, lack of management support and apathy by lecturers and students is a poor reflection on the university. Notwithstanding, the recent request to senate for approval of the e-learning Implementation Strategy and Plan is a step in the right direction.

The University of Pretoria, one of the largest residential universities in South Africa with over 40000 students, in the late 90's embarked on a major exercise which involved changing the campus into a virtual campus.[19] The University of Pretoria has been credited as being one that has provided the resources for the promotion of e-learning. Their policies have been based on both financial and academic reasons. The academic reasons include the challenges faced by lecturers in dealing with large student numbers. E-learning provides an opportunity for the academics to interact and communicate with their students thus enhancing the learning activity. On the students side there are opportunities for them to avail themselves to a variety of learning materials that were previously not available prior to the adoption of e-learning. Academic and technology experts drive the process.[20] The success of University of Pretoria's implementation is measured by the support of the university management in terms of their policies and strategies for e-Learning; the availability of resources; the willingness of academics and students to adapt to the new e-learning philosophy. It is interesting to note that one of the factors that weighed heavily in favour of the University of Pretoria's successful implementation of e-learning as compared against a disadvantaged university like the University of Zululand was the financial resources available to them. The legacy of underfunding or disproportionate funding by the state of disadvantaged universities still haunts them some 20 years after democracy.

The University of KwaZulu Natal (UKZN) has now moved beyond the class room in announcing it has become the "… first interactive classroom in the country" and has started the process of equipping their students with their own "state-of-the-art tablets" The university has provide the first batch of 1000 students from the College of Health Sciences with the tablets as part of a pilot Visual Learning Project.[21] This project is a way in which the UKZN is adapting to the continuous change in technology. The university with over 40000 students split over five campuses [22), like other similar universities is faced with the challenges of large class and tutorial groups, difficulties in students not always being able to attend lectures due to various reasons and the cost of resources. The tablets allows for students to be part of an interactive classroom that includes student and lecturer interaction electronically. The advantage of the system is that it enables students who are not in a lecture room to still be part of the lecture from any location they might be in. An interesting research finding is that there "… was no correlation between student pass rates and attendance…" which translates into students using their tablets not only to be part of the lecture but also using their device to download the content of the lectures from the internet .[23] In order for this venture by UKZN to succeed and be adoptable by other universities, a solution needs to be found for the funding of tablets and provision of cheap internet or wireless connection.

The University of South Africa (Unisa) with a student enrolment of over 350000 spanning 130 countries around the world is considered the largest open distance learning institution in Africa and is the longest standing dedicated distance education institution in the world. Unisa because of the huge challenge of large student numbers were forced to find ways in which it could deal with these students not only for communication but for learning as well.[24] MyUnisa is an all inclusive learning and teaching system that is used by lecturers, tutors and students to provide an enabling environment that allows all parties to the learning environment to interact with each other and to draw on the available resources including, study materials, communication facilities and administrative tools. [25] The success of Unisa's e-learning exercise has come at a cost. Academics and students needed to be trained in e-learning technology. The changing role of the lecturer in a technologically charged world required the re-skilling and a move away from the traditional way of classroom learning.

In a study amongst first year students at the University of Free State (UFS), it was found that the large numbers of students in the different courses made it difficult for them to interact with other learners as well as with course materials. UFS has a student enrolment of 33000 students and is one of the oldest institutions of higher institutions in South Africa. [26] In addressing the challenges the UFS found that by providing "… online lecture notes, quizzes, tests and online discussions to supplement the traditional lectures…" students were able to cope with the demands of university education. This also helped them to improve their educational and learning skills. On the lecturing side lectures were able to communicate better with students and were also able to place notes and other learning material on-line.[27] This may be viewed as a small move towards e-learning but it is one that has the buy-in from the academics and the students. Students now feel that it is easier for them to concentrate in the classroom because they no longer had the pressure of trying to take down notes as the lecturer spoke.

The University of Western Cape (UWC) which was established in 1959 by the South African government initially as a university for Coloured people, has a student enrolment of over 15000 students. Like all other previously disadvantaged institutions of higher learning UWC face the challenge of inadequate resources which impacts on their ability to sufficiently provide for the technological needs of their academics and students. In addition their students come predominantly from disadvantaged backgrounds and therefore are not in the favourable position of owning their own computers and have to rely heavily on the limited number provided by the university.[28] Notwithstanding the University of Western Cape's own limitations, it has realised the need to adapt to technological changes in the learning environment by establishing an e-learning Division which is aimed at assisting their academics, tutors and student with the necessary skills. Beyond the training and support provided this new division aims to provides an holistic function which includes the changing of mindsets of UWC's community towards the effective use of information technology in teaching and learning.[29]

The Mangosuthu University of Technology (MUT) with a student enrolment of 10000 is another of the former disadvantaged institutions of higher learning, faces similar challenges to the UWC which include limited resources, low student income, lack of infrastructure, and students from disadvantaged backgrounds. As part of its vision statement the university seeks to promote technology development and to manage innovation resulting from technological development. Only recently the University has embarked on an e-learning programme that encourages lecturers to attend the Black Board Training programme which as pointed out above is one of the many tools that promotes e-learning. The down side of this is that this training is not compulsory and lecturers only attend out of choice. In addition after the lecturers have been trained they are then left with the responsibility of training their students in the use of the Black Board programme. Too few if any lecturers are willing to do this. Also the question that needs to be asked: How many students are prepared to give up their time to learn how the systems works. The university is presently still grappling with the idea of employing an e-learning specialist to drive the e-learning process.[30]

In total there are 23 public institutions of higher learning that offer a range of qualifications. These institutions are subsidized by the state and rely heavily on this source of funding more especially in light of the diminishing income from student fees. Some of these universities as pointed out above are at a more disadvantaged situation than others because of the political history of this country.[31] The preceding discussion on the institutions of higher learning provides an overview of some of the e-learning practices that takes place at these institutions. It is important to note that while all universities have realised the benefits of e-learning and have taken steps to implement this innovation, not all institutions are sufficiently resourced to spend huge amounts of money to make this change overnight. While the more privileged universities in terms of resources and infrastructure are making steady progress towards meeting the challenges that face them, other universities more especially the previously disadvantaged ones are finding it difficult to move at the same speed. The constant battle with student's failure to pay their university fees and the limited government subsidies contribute to institutions of higher learning failing to transform their learning environment to an e-learning one at greater pace.

7. Predicting the future

The effects of technological advancement have affected all nations across the world. Institutions of learning have also felt the need to transform into e-learning institutions in order to meet the challenges that confront them which include the increase in student numbers, large classes, and lack of space, location, finance, and resources. E-learning definitely has value and could be seen as an integral part of education and learning in future

The government has also started speaking about "blended learning". This concept of e-learning supporting class room learning is seen by the Minister of Public Service and Administration as a way to go in future. In addition in the business sector more especially Nedbank and First National Bank have transformed themselves into digital environments that allows a customer to do a majority of their banking functions electronically thus removing the paper trial from their interactions. The use of computer and cell phone technology in these institutions is seen as a huge breakthrough that enhances the chances of institutions to transform into e-learning institutions.[32] In the same way the customers of financial institutions can be in any location and transact with their banks, the learners could be doing this in future.

While the rest of the world have not escaped the challenges brought about by e-learning the challenges facing South African institutions have shown that some of them are unique to our country in terms of our apartheid past, the large number of the population that are uneducated, the inferior schooling system, remote rural areas with little of no infrastructure, for example, housing, water and electricity, high levels of unemployment and the increasing rate poverty. Against this background the future growth in e-learning must be determined. Research has shown that large numbers of scholars and university students are already reaping the benefits of technology in their own social networking and classroom learning. This activity should be encouraged with technological experts exploring more ways in which the existing tools for example cell phones, Ipads. I-phones etc can be enhanced to provide greater use as learning instruments. Other learning institutions should also consider the recent announcement by the University of KwaZulu Natal of providing their students with special priced Ipads in order for their students to be part of an interactive learning environment that transforms the ordinary classroom to a virtual one. The future could see a “blended” approach become a norm if we could find ways to overcome the cost, infrastructure and resource implications.

The cost of electricity and the lack thereof in rural areas in South Africa contributes to their lack of infrastructure thus denying millions of youth exposure to modern technology and the benefits associated with it. Cheaper cost of power and electricity must be explored. The provision of power for the use of computers and laptops or for that matter cell phone technology is cheaper than normal electricity and therefore should be given serious attention. This problem if left unattended will increase the challenges faced by under resourced schools and problems of ill prepared students going into universities will expand.. Technology if properly managed and with the right infrastructure could becomes self-sufficient. Education institutions and the Government must jointly address the e-learning problem. The benefits of e-learning must be seen as a win-win situation for all stakeholders. Investments in digital classroom are an investment toward the future. Policies must be put in place by both government and educational institutions. These policies must be able to compliment each other and must be supported by the private sector with the realisation that these endeavours contribute to strong economy that benefits everyone. The support of the authorities from institutions of higher learning is essential in this advancement.

The conversion to virtualisation is not as far fetched as it seems. UKZN has demonstrated its endeavours in this regard. Couple this with advancement in cloud computer technology, (a concept that denotes the use of several computers over a common network that enhances communication), and Google’s balloon technology (to provide internet link to even the remotest of areas) is gaining momentum.[33] These are positive moves for the e-learning environment. The internet increases the interaction at a local, national and international level. It increases communication and enhances the learning environment. The provision of computer technology for students and teaching staff at institutions of higher learning is an area that needs serious attention. Some of the institutions of higher learning have only recently developed e-learning policies and have established e-learning divisions. In addition these institutions have provided ‘hot spot’ areas on campuses where staff and students can access the internet at no cost to themselves. These institutions have suddenly realized that this change is necessary and there is no avoiding it. The rapid changes in technology, the increasing number of student in institutions and the lack of classroom infrastructure has made e-Learning not a nice to have but an essential component of teaching. Computer technology has become integral to education and cannot be avoided.

Students at universities have been motivated by the support received from online lecture notes, exercises and information, They have found that this helps them to cope better with their studies because it becomes easier for them to deal with the on-line notes instead of having to create their own. In addition the ability to communicate directly with their lecturers and tutors enhances their learning. Training and development of educators, learners and tutors is essential in the e-learning process. The numerous programs such as Blackboard, Moodle and Web 2.0 need to be taught to the users and should become compulsory to use. If the benefits of e-learning are to be fully realised then all the role players must take responsibility.

8. Conclusion

The preceding discussion highlighted the different levels of e-learning both from an international, national and local perspective. While this discussion is far from exhaustive, the brief overview provided gives an indication of e-learning usage that could in some small way contribute to the factors that need consideration when the discussion takes place at institutional level.

The increase in student numbers, the lack of resources, technological changes and infrastructure, training capacity, apathy by users, institutional policy, institutional priorities, etc. are factors that will determine an institutional willingness to change. The advantages of e-learning can be clearly seen but needs to be weighed against the traditional methods of education and learning. The concept of 'blended learning', which allows both e-learning and traditional learning to co exist is a consideration, that's worth exploring.

The concept cloud technology and the innovation of 'balloon technology' by Google aimed at providing internet service to people in the remotest of areas is a noble idea but can only be of value to e-learning in third world countries like South Africa if the cost of internet service comes to its users at a far reduced cost than what is presently the case. In addition the cost of electricity and provision thereof need to come at a cheaper rate more especially for computer use. E-learning is a way for the future which cannot be ignored but in order for it to be a success alternative ways of funding infrastructural and technology cost must be sought.

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Learning in Virtual Environment (LIVE)- Assessing Impact of Web-Based Simulation and Visualization Modules on Student Learning

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Abstract

This paper presents results from a research project that was aimed at enhancing student learning effectiveness by developing and integrating web-based simulation and visualization modules in several engineering science lecture and laboratory courses at Old Dominion University. The main hypothesis of this work can be stated as follows: "Since current engineering students are constantly exposed to visualization in the virtual domain through computers, Internet and video gaming, they are more likely to use and benefit from highly interactive visual and user-friendly web-based modules, used for supplementation of conventional learning". To test this hypothesis several web-based modules have been created and embedded in two undergraduate courses namely thermodynamics-I and thermo-fluids laboratory of the mechanical engineering curriculum. Assessment instruments and statistical experimental design have been developed and implemented. Assessment of modules has been done in a rigorous and systematic manner so that results are valid and reliable to establish the web-based supplementation pedagogy on a firm ground. The research design for assessment of student learning effectiveness was based on the Intact-Group method. For quantitative assessment, both "Control" and "Experimental" student groups were employed. Both quantitative as well as qualitative results indicate that students' learning effectiveness improved when they used the web-based modules in the supplementation mode.

Keywords: *Visualization, Simulation, Web-based, Virtual environment.*

1. Introduction

Engineering education, like many other fields, is being shaped by the digital revolution. A review of recent engineering education literature indicates that an increasing number of engineering educators are employing technology tools such as computers and Internet to develop educational resources to enhance quality of engineering education and serve distance learners [1-12]. This paper summarizes results from two ongoing National Science Foundation supported engineering education projects titled "Simulation and Visualization Enhanced Engineering Education" and "Engineering laboratory Instructions in Immersive Virtual Environment (ENLIIVEN)". In both projects, web-based simulation and visualization modules have been developed, implemented and assessed in a number of undergraduate engineering courses to analyze their impact on student learning effectiveness.

Six factors currently favor development of web-based engineering education. They are : a) advances in technology; (b) current student learning style that is becoming more and more visualization based; (c) globalization of the engineering profession; (d) growing base of non-traditional and geographically distributed students; (e) cost effectiveness of cyber infrastructure and, (f) emergence of global standards for engineering education and transnational collaboration among institutions.

Advances in technology have made it possible to deliver engineering education in anytime/anywhere mode on the web. As a result, a single node of engineering education can serve practically an unlimited number of geographically distributed nodes. The massive offering of open courses (MOOC) is a recent example of it. High speed digital service lines (DSL) permit video streaming of course content over the Internet either synchronously or asynchronously, thereby reaching a large number of geographically distributed engineering students who otherwise would not have been able to pursue engineering education.

Engineering schools around the world have been educating engineers using the conventional teacher-centric model in which engineering fundamentals and skills are inculcated in students in centralized classrooms settings. In the technology enhanced teacher-centric model, also known as technology enhance learning (TEL), technology tools are used to supplement student learning achieved through conventional teacher-centric pedagogy. The present work, in keeping with the ongoing trend of technology infusion in engineering education, has leveraged computer-based simulation and visualization to develop web-based modules for two mechanical engineering courses namely; thermodynamics I (MAE 311) and thermo-fluids laboratory (MAE 305). The modules are designed to be interactive so that students can be engaged in active learning outside the classroom. This is expected to transform students from being passive learners, an often cited criticism of teacher-centric pedagogy, to self learners. Supplementation of conventional in class learning with web-based simulation and visualization modules is expected to enhance students' learning effectiveness by making the learning process more engaging.

2. Description of the Modules

Table 1 gives the list of modules that were developed at Old Dominion University (ODU) for implementation at ODU as well as its partner institution East Carolina University (ECU). The thermodynamic course represents a required two-course sequence in the mechanical engineering curriculum that deals with the laws and applications of thermodynamics. The thermo-fluids laboratory (MAE 305) is a one credit course that introduces students to measurement and data analysis techniques involving pressure, temperature, velocity, flow and force measurements. The module in the lecture classes (MAE 311) is being used for reinforcement of concepts and principles presented in lecture classes. The virtual experiment module is used primarily for web-based pre-lab practice sessions to prepare students for the corresponding physical experiment in the thermo-fluids laboratory (MAE 305) course.

Figure 1 shows the example of interactive simulation of the physical experiment titled "Jet Impact Force". In this experiment students measure the jet impact force as a function of jet mass flow rate and the jet deflection angle induced by a vane. The 2-D virtual analog shown in Fig. 1 mimics closely the physical experiment set-up, process and various steps involved in performing the experiment. In order to create more realism, a 3-D immersive virtual analog of the experiment (Fig.2) has also been developed and implemented. It is to be noted that the 2-D virtual model requires less developmental effort as well as a desktop or a laptop computer to implement. Based on the results of extensive testing, it appears to be an effective tool for web-based pre-lab practice sessions for preparing students for physical experiments. In this hybrid learning mode both virtual and physical experiments are employed synergistically to enrich students' laboratory experience. The 3-D immersive virtual experiment is more realistic but it requires much larger effort (cost) to develop and implement. For example a 3-D TV screen or a multi-wall projection system in a CAVE (Cave Automatic Virtual Environment) is required. The 3-D immersive model may be more appropriate for stand-alone applications such as virtual laboratories for a web-based program. The assessment process to determine the impact of the 3-D model on student learning is still in progress and results from it will be reported in a future paper. However, 2-D virtual experiments and web-based modules for lecture classes have been fully assessed, and results are discussed in the next section.

3. Quantitative Assessment

Assessment of modules was done in a rigorous and systematic manner so as to establish the proposed web-based supplementation pedagogy on firm ground. Quantitative and qualitative assessments were used to characterize module's effectiveness in enhancing student learning. For all modules, a number of module objectives and outcomes were formulated and module contents were developed for knowledge, comprehension and analysis of cognitive levels as per Bloom's taxonomy. For each module, a "control" group and an "experimental" group were established. The "control" group consists of students who did not have access to the web-based module. This group was also referred to as the " pre-implementation" or " without module" group. Students' learning of the subject matter in this module was mainly due to conventional classroom lectures and/or laboratories. Students in the "experimental" group supplemented their in-class learning using web-based modules. This group was referred to as the "with module" or "post implementation" group. In most courses, prior to introducing the module in a given semester, the entire class was first taught conventionally without the module, in the preceding semester. This group was used as the "control" group.

Table 1. list of the developed modules and their outcomes

Module Title /Course	Module Outcomes
"Jet Impact Force" www.mem.odu.edu/jetforce MAE 305	-Students will have the ability to conduct various activities, involved in the physical experiment. -Students will have the ability to take data, to develop correlations between jet impact force and mass flow rate, to predict expected trends using theoretical considerations and to characterize potential sources of errors.
"Brayton Cycle" www.mem.odu.edu/thermodynamika/brayton_cycle MAE 311	-Students will be able to determine performance of individual components such as compressor, turbine and heat exchangers by using the first and second laws of thermodynamics -Students will be able to define stage efficiency for compressors and turbines and will be able to calculate overall efficiencies of multistage compressors and turbines as a function of stage efficiency and overall pressure ratio. They will also be able to perform calculations pertaining to multistage compressor with intercooling. -Students will be able to integrate individual component performance to analyze and deduce trends in overall cycle performance as a function of pressure ratio, component efficiencies, maximum cycle temperatures, regenerative heat exchange and intercooling.
"Steam Power Cycles" www.mem.odu.edu/thermodynamika/steam_power_cycle MAE 311	-Students will be able to determine performance of individual components such as turbine, pumps and reheaters using the first and second laws of thermodynamics. -Students will be able to integrate individual components to analyze and deduce trends in overall cycle performance as a function of boiler pressure, component efficiencies, reheater pressure and ambient wet-bulb temperature.

Both "control" and "experimental" groups were administered an identical quiz or test to gage student performance in the subject area pertaining to a particular module. All other factors remain the same. Any increase in class quiz average for "experimental" group over the "control" group should be attributed to the module. However, there are factors other than the module such as gender, race, academic background etc. That may have influenced students test performance. Also, the question of statistical significance of

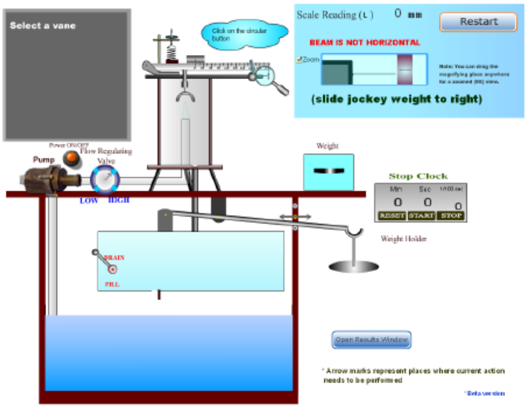

Figure 1. Physical set-up and the 2-D virtual experiment.

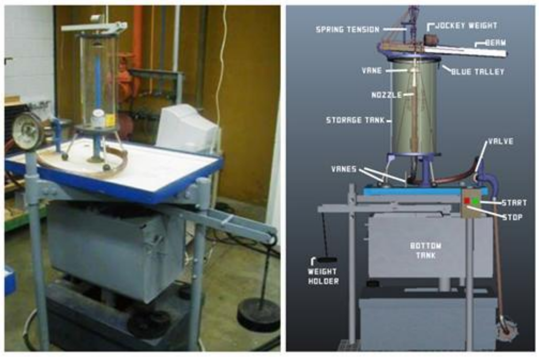

Figure 2. Physical set-up and the 2-D virtual experiment.

learning enhancement due to a module needs to be addressed. Measurement of learning or learning enhancement is a very challenging issue, since it can be affected by a myriad of parameters. In order to illustrate the present approach to this complex topic, a formal relationship between learning, the dependant variable and other variables x_1, x_2, ….., x_n and module is assumed to exist. Learning functions for "control" group and "experimental" group can be expressed symbolically as,

$(\text{Learning})_{\text{control}} = f\,(x_1, x_2, \ldots, x_n)$
$(\text{Learning})_{\text{experimental}} = f(x_1, x_2, \ldots, x_n, \text{module})$

A statistical analysis was used to determine if variables x_1, x_2, ….., x_n are statistically significant for observed learning gain. Ideally, the results of this study would become much easier to interpret if one can identify parameters x_1, x_2, ….., x_n and establish that these variables do not significantly influence learning gain in a statistical sense. In that case the learning gain can be attributed solely to module introduction.

4. Statistical Experimental Design

Both "control" and "experimental" groups for each module in MAE 305 and ME 311 courses were given identical multiple choice quiz to gage student knowledge of module related subject matter. Students in the "experimental" group, using the module, consistently outperformed students in the "control" group for all seven outcomes pertaining to three modules in the two courses considered in this study. A statistical analysis was performed on quiz results for both "control" and "experimental" groups to determine if enhanced learning was due to the implemented module as indicated by higher quiz scores for the experimental groups is statistically significant or not.

Since students' demographic data can also contribute to student learning, ten factors were identified based on their potential influence on students' performance on quizzes. Theses demographic factors are: student level (senior, junior etc.), gender, ethnicity, age, current cumulative GPA, course load, student track (transfer or regular student), high school GPA, verbal and math SAT scores. The quiz scores along with the demographic data collected for both "control" and "experimental" groups were tested for normality using the Shapiro-Wilk W statistics [13]. Results indicated non-normality for many data sets involving demographic factors and quiz scores. To address the non-normality problem in the data, Wilcoxon Rank Sum statistics [14] was used to test the hypothesis of central tendency and dispersion to compare paired median as well as variance for all quiz scores at 95% confidence level (α=0.05). The following null and alternate hypotheses were tested

H_0: $\tilde{\mu}$ [quiz score {Pre-module}] = $\tilde{\mu}$ [quiz score{post module}]

H_a: $\tilde{\mu}$ [quiz score {Pre-module}] < or > $\tilde{\mu}$ [quiz score{post module }]

At 95% confidence level, if Wilcoxon Rank Sum *p*-value is less than 0.05, then a conclusion can be made that there is a significant difference between the mean quiz scores of the pre- and post-module settings. Once pre- and post-module comparisons were made, students' demographic data variables were also compared by quiz success to identify any potential influence of demographic factors toward quiz scores. This was done using null and alternate hypothesis similar to the ones used for testing module effectiveness.

H_0: $\tilde{\mu}$ [quiz score{pre-module/DemoVar}] = $\tilde{\mu}$ [quiz score{post-module/DemoVar}]

H_a: $\tilde{\mu}$ [quiz score{pre-module/DemoVar }] < or > $\tilde{\mu}$ [quiz score{post-module/DemoVar }]

In the same manner, at 95% confidence level, if Wilcoxon Rank Sum *p*-value is less than 0.05, then a conclusion can be made that there is a significant difference between mean quiz scores of the "control" and "experimental" groups due to contribution by the particular demographic variables.

5. Discussion of Results

Table 2 summarizes the results of the statistical analysis for all three modules. For MAE 311, there are 12 students in the "control" group and 35 students in the "experiment" group. For MAE 305, there are 15 students in the "control" group and 17students in the "experiment" group. The thermo-fluids lab virtual module has two outcomes that were tested by administering two quizzes. The "Brayton Cycle" module (listed as module 1) has two outcomes that were assessed using two quizzes and the "Steam Power Cycle" module has three outcomes that were assessed by administering three quizzes. It is noted that the *p*-values for the MAE 305 module were respectively 0.0278 and 0.0165, indicating that the implemented virtual experiment module did enhance student learning. For module 1 of MAE 311 course the first outcome had a *p*-value of 0.0034, indicating that this module is effective in enhancing student learning related to outcome 1 of the module. The same conclusion applies to outcome 2 since the *p*-value is 0.0058 (<0.05). For module 2 of the MAE 311 course for only one outcome (number 3) the null hypothesis could be rejected (p <0.05). For both outcomes 1 and 2 the *p*-values are greater than 0.05 even though mean quiz scores showed that the "experimental" group performed better than the "control" group. In the statistical sense the improvement in learning was not significant for both outcomes 1 and 2.

Table 2. P-values for different outcomes

	Outcome 1	Outcome 2	Outcome 3
MAE 305 Virtual Experiment	0.0278	0.0165	---
MAE 311 (Module 1)	0.0034	0.0058	---
MAE 312 (Module 2)	0.106	0.1721	0.0273

Table 3 gives a list of demographic factors that contribute to student learning. As it was noted earlier it would be very desirable if none of the 10 demographic factors contributed significantly to students learning enhancement. Table 3 shows that the MAE 305 virtual module is such a module in which none of the demographic factors impacted student learning. However, in modules I and II of MAE 311 course three factors namely; student level, age, and cumulative GPA contributed significantly. Senior students performed better in the quizzes compared to juniors, primarily due to higher maturity level. Students in higher age group performed better than students in lower levels, perhaps due to the fact that higher age group students tend to be more dedicated to pursuing the degree program successfully. Finally, the higher cumulative GPA students performed better in quizzes compared to students with lower cumulative GPA. Students with higher academic credentials tend to be more motivated and connected to the learning process in and outside the classrooms.

Table 3. Summary of results from the statistical analysis of demographic factors.

	MAE 305 (Virtual experiment)	MAE 311 (Module 1)	ME 311 (Module 2)
Gender	NO	NO	NO
Ethnicity	NO	NO	NO
Student level	NO	YES	YES
Age	NO	YES	NO
Course load	NO	NO	NO
Current cumulative GPA	NO	YES	YES
Track	NO	NO	NO
SAT verbal	NO	NO	NO
SAT math	NO	NO	NO
High school GPA	NO	NO	NO

NO: Factor not significant, YES: Factor significant

6. Qualitative Assessment

The qualitative assessment of the thermal-fluids and the thermodynamics I modules were performed at Old Dominion University(ODU) and at East Carolina University (ECU). Students were given survey forms containing questions framed to capture qualitative feedback from students concerning various aspects of the modules. The survey form used the Likert scale of 1 to 5, with number one and five signifying students' strong disagreement and strong agreement respectively with a posed question.

Table 4 shows the weighted averages for the questions in the student surveys conducted in the thermal-fluids laboratory course. The physical experiment and lab instructions in the thermo-fluids lab at ECU are similar to the one at ODU. The student feedback at ECU was obtained for the same questions that were also used for the thermo-fluids laboratory at ODU. As noted from Table 4, student groups at both ECU and ODU generally had a positive feedback about the usefulness of the virtual experiment for pre-lab practice session. Most of the received comments from students were positive and two of these comments are provided below:

"I find the virtual experiment to be better because it makes you do go through the Experimental procedure first before you do the lab itself first. That's good because I know a lot of people who went into the lab unprepared and haven't read the lab reports before actually doing the lab. This virtual experiment explains everything step-by-step and if you don't understand anything such as the calculations you press the "explain me" button and it explains all the calculations. The visualizations were great and the explanations were awesome.....I "Strongly Agree" with all of them. The only problem I would have with the virtual experiment is if I had any questions who would I ask? However, this virtual experiment is great and very detailed and well explained that I had no questions.... "

"It was very interactive and very user friendly. The only way to get a better understanding of the lab was actually doing it. This virtual lab had everything laid out in an easy to understand format that a student could do at their own pace. It really prepares someone about to do the lab in real life. The visual effects were good and contributed vastly to the effectiveness overall. The only problem I had, been in the virtual interactive exercise .Other than that it was great."

Table 4. Students' responses with averaged score for each question

Questions	ODU	ECU
1. The prelab practice module was helpful in understanding activities involved in experimental procedure.	4.8	4.4
2. The module improved my understanding of what parameters needed to be measured in the physical experiment.	4.8	4.15
3. After reviewing the module, I had a better understanding of potential errors involved in the experiment.	4.8	4.45
4. The module enhanced my understanding of theoretical basis for relationship between the jet impact force and the mass flowrate.	4	4.3
5. Overall, the module was effective in preparing me for the actual physical experiment session.	4.8	4.45
6. The module, through simulation and visual effects, replicated the actual physical experiment well.	4.8	4.25
7. More visualization modules of the type presented here should be developed for other physical experiments in the laboratory.	4.6	4
8. The prelab practice module was user friendly.	4.4	3.9
9. The time allocated for reviewing the module was adequate.	4.6	3.75
10. The dynamic visual images in the module helped me retain information for a longer time compared to the laboratory manual.	4.6	4.15
11. The module exposed me to information not readily available in the lab manual.	4.8	3.9

The questions of the thermodynamics I survey conducted at ODU and ECU are : (1)The visualization module was helpful in understanding thermodynamic states of a pure substance, (2) The visualization module was helpful in understanding thermodynamic tables of pure substances, (3) The visual image in the module helped me understand interrelationships between various thermodynamic properties, (4) The visual images in the module will help me retain concept and other related information for a longer period of time, (5) The examples presented visually, were very helpful in understanding how to use thermodynamics tables. (6)The visualization module was user friendly. (7)It is recommended to use this visualization module in future classes, (8) More visualization modules of the type presented here should be developed for other topical areas.

The averages for the eight questions in the student surveys are shown in Fig.3. In general, the average rating of all question of the survey by ODU students and ECU students are 3.6 and 4.1 respectively on a scale of 1-5. Question 5 received the lowest average rating (3.3) suggesting that more examples are needed.

7. Conclusion

This paper presents results from two projects funded by the US National Science Foundation (NSF). Through these projects, web-based modules were developed, implemented and assessed for two courses

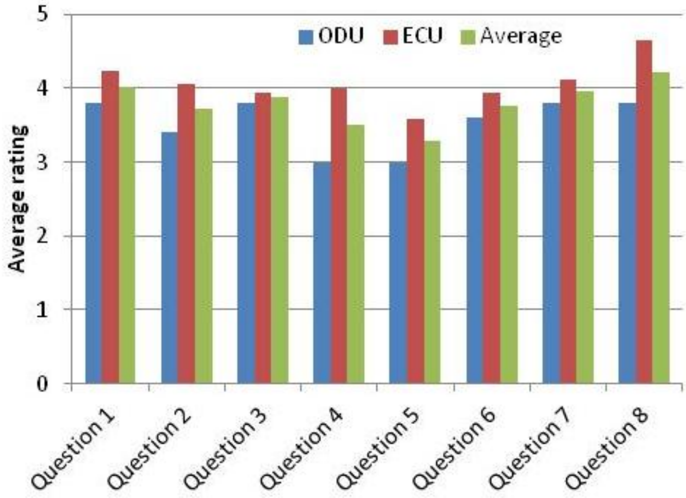

Figure 3: Results of the student feedback survey.

in the mechanical engineering curriculum at Old Dominion University namely thermodynamics-I (MAE 311) and thermo-fluids laboratory (MAE 305). The primary goal of the projects was to enhance student learning effectiveness by developing and integrating web-based simulation and visualization modules in these courses. Assessment instruments and statistical experimental design have been developed and implemented to objectively determine if an implemented module used in supplementation mode enhances students' learning effectiveness compared to pre-implementation setting, and also test if gain in learning is statistically significant or not. Implementation of these technology tools is not only transforming the way faculty teaches but it is also closely aligned to the ongoing transformation of engineering education from a traditional teacher–centric learning to emergent student-centric learning style, a modality in which students are the focal point of the learning process. Using easy access to web-based resources discussed in this paper, students are increasingly learning in the anytime-anywhere mode.

Quantitative assessment of results, using statistical analysis of quiz scores, indicates that web-based simulation and visualization modules are effective in enhancing student learning when used for supplementing in class learning. The demographic factor analysis shows that of ten demographic factors considered only three namely, current cumulative GPA, student level and age contribute significantly to student learning. The other seven demographic factors such as gender equity etc. do not contribute to student learning. In other words male and female students perform equally well statistically when using web-based modules. The qualitative analysis, using student surveys indicates that students consider web-based modules to be helpful tools in the learning process.

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Presenter: The paper is presented Sushil Chaturvedi

Security Aspects of Online Teaching and Learning: An ODL Case Study

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Abstract

The Open distance learning (ODL) model caters for a wider audience, unlike the full-contact model; the students are not located at one location. This means learning takes a completely different route, and over the years technology has been widely used to deliver and support teaching and learning. Online platform use for teaching and learning (OTL) has rapidly grown over in recent years. There is much talk of the convenience and accessibility of e-learning and e-assessment. There are security issues with regards to e-assessment as it can be difficult to authenticate students remotely. This paper draws attention to the security aspects to be considered when online platforms are used in teaching and learning. Using the University of South Africa's online portal as a case study, we report possible security problems encountered by students and facilitators alike. The paper proposes a framework for securing e-learning and e-assessment systems. The framework will incorporate security measures to be considered from both the student's and ODL institution's perspectives. This helps in the development of secure and usable e-learning tools.

Keywords: *e-learning, e-assessment, ODL, security*.

1. Introduction

Distance learning institutions have embraced the use of information and communication technology (ICT) to deliver teaching and learning content to the distantly located student. This trend has seen a proliferation of online learning platforms production. This includes off-the-shelf products and some tailor-made for specific institutions' needs. Even though teaching and learning have transferred to the online spectrum, its accessibility for the majority of students in developing countries is still a major challenge due to the countries' legacy internet connectivity problems. Those in rural areas are further constrained by the lack of infrastructure, which introduces a severe obstacle to full adoption of the model by institutions as they are forced to provide alternative modes of teaching and learning to those students still struggling to come aboard the digital highway. In some cases, ODL institutions are compelled to provide internet connectivity to students through initiatives like subsidizing bandwidth costs, partnerships with internet services providers (ISPs) and internet café operators. As a result, ODL institutions end up running two parallel models of content delivery; online and print delivery models. This results in a lack of optimization and the benefits of online delivery not being fully realized. In the case of situations where e-learning adoption has been embraced to a larger extent, the problem is that of conducting summative assessment.

ODL Institutions such as UNISA are faced with logistic problems when organizing venues for venue-based summative assessments, given the increasing number of students. The focus of this paper is on the problems encountered when conducting summative assessment online, in the context of ODL environment. Even when tuition is delivered online, summative assessments are conducted in as venue-based in designated examination centers to reduce the chances of students taking assessments on behalf of others (student impersonations). The security of summative e-learning was investigated in literature and a framework for securing e-learning and e-assessment systems was proposed. A qualitative method with a case study approach was followed for this paper, in the form of an exploratory type with a Short-term, contemporary time focus. The paper aimed to address the following questions: What are the issues affecting e-learning and e-assessment? And; how can these issues should be addressed? The issues to be addressed are documented in the E-Learning Security Concerns section, section 4. The ways in which these issues can be addressed are noted in the Proposed Framework for E-learning Security, section 4.1.

2. Literature Review

2.1. E-Learning

Electronic learning (e-learning) is the use of information technology tools for learning purposes [1]. E-learning uses electronic channels for communication and delivery of the teaching and learning content to the students. E-learning started as the use of electronic devices such as CDs, DVDs and tapes, which were sent to students and the content opened through a computer, but has now extended to then online mode of delivery [2]. A typical online learning platform provides tools such as discussion forums, video and audio podcasts and electronic documents. It usually involves a two-way communication between students and the institution. According to [3], e-learning qualifies as a type of distance learning as the educator and the student are often in different locations with asynchronous means of interacting. [4] as well as [5] present the characteristics of e-learning systems as follows: learning takes place in a virtual class that is coordinated by a facilitator, the content is made available over the internet, learning is a social process, there is activity monitoring of the participants and the environment allows the transfer of knowledge and skills.

Online learning brings about a number of benefits to both the student and the institution. Previous studies identified flexibility to the student as it allows them to collaborate online without the need to rearrange one's schedule [6]-[8], especially for those students studying part-time and working full-time. Such flexibility is not available in residential institutions. Convenience of choosing the most suitable time to engage with online learning tools is another strength reported by students [9].

2.2. E-Assessment

While delivering tuition content online there has to be a way in which the students are assessed in order to credit them for the coursework completed. Electronic assessment (e-assessment) is the use of computers and computer software to administer and assess the learners' work [10]. This usually entails a non-venue based examination, where students log on to the system and undertake an automatically timed assessment. Based on the system sophistication, results can be displayed immediately or be made available at a later stage. E-assessment is often seen as providing a partial solution to providing assessment for increasing numbers of students and declining staff to student ratios. It is important that as an institution takes learning and teaching online, assessment also has to be conducted online. Since students might experience cognitive conflict when assessed differently from the way they were taught [11] [12].

A '*true*' e-assessment model where students can take an assessment online from anywhere without any form of supervision is currently impractical [5]. They suggest the need for physical security to cover this aspect. Hence e-assessment will be confined to the use of computers and internet in a controlled and monitored environment, until such time when security mechanisms are found to conduct "*anywhere, anytime*" e-assessments. Unfortunately e-learning and e-assessment inherits some of the security problems from the internet as the underlying platform. Therefore apart from internet security problems there are those specific to e-learning and in particular e-assessment. Consequently, while using online teaching, summative assessments are venue-based due to logistics and security concerns in e-the assessment model. Some institutions, are embracing non-venue based assessments also known as electronic assessment (e-assessment). E-assessment model comes with its own problems such as limited bandwidth and auto-timed e-assessments where students face the risk of not finishing in time due to interrupted connectivity. Therefore, some institutions provide the infrastructure for e-assessment such as computer laboratories with high-speed internet and this becomes a form of online venue-based e-assessment. Secondly, the major concern in e-assessment when all infrastructure hurdles are eliminated is security, especially ensuring the identity of an alleged e-assessment candidate in an unsupervised online environment. The security problem still exists in formative assessments that students submit online and in-print for distance learning environments. But this is mitigated by awarding a lower weight in formative assessment than that for the venue-based summative assessment for the final grading of a module. [5] supports this view in stating that It is not possible to ascertain the student identity if they are physically in a different location.

2.3. Online Learning Infrastructure

ICT Infrastructure

Technological infrastructure refers to all the aspects of ICT facilities that need to be in place for the introduction of ICT in the classroom, this include ICT devices and networks. The schools need to have proper facilities such as computers with a functional operating system and connected to the internet through faster and usable bandwidth speeds that allows communication with reasonable speeds. Virtual learning environment (VLE), also known as e-learning platform or learning management system (LMS) is a set of learning and teaching tools such as discussions, electronic documents and learning units usually provided through a web portal [13].

E-learning platforms are becoming an integral part of the teaching and learning process [14], but the main problem in developing countries is the high cost and limited bandwidth and schools are affected most because they have limited financial resources. At the core of online learning is the internet, since it is the delivery medium of online content [15]. Most of the online content delivery services such as video and audio streaming or playback require high-speed internet compared to browsing [16] [17]. Internet coverage and e-learning implementation in developing economies, especially in Africa, still prove to be a challenge due to lack of infrastructure, particularly, broadband [18].

Human Infrastructure

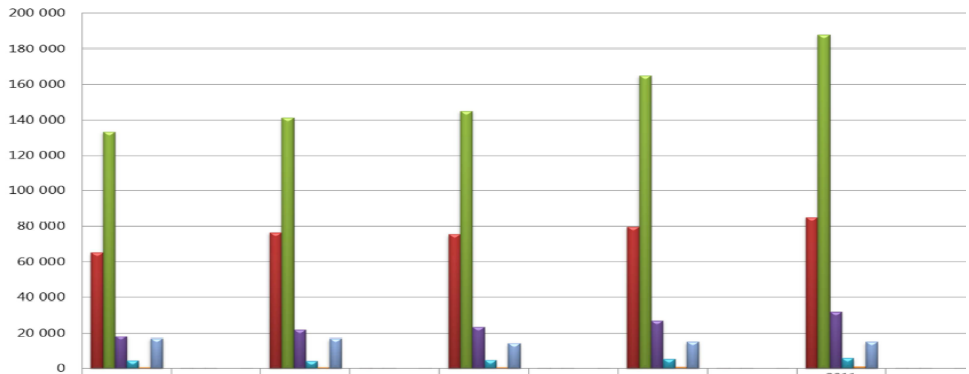
The shift from traditional teaching and learning to OTL brings about a number of challenges for both the student and the institution. At the fore front it's the need to train instructors and prepare them for the new way of teaching and learning. That way, they will be better equipped to utilize the infrastructure and assist students in OTL. [19] found that instructor's behaviour determines the success of online learning model, as there are significant differences between the behavior of online instructors and classroom instructors. This suggests that instructors need to be prepared for online learning delivery, mostly through training in ways of interacting with students through online tools.

3. UNISA ODL Model

UNISA is the largest open and distance learning (ODL) university in Africa. UNISA ODL policy defines ODL as:

"a multi-dimensional concept aimed at bridging the time, geographical, economic, social, educational and communication distance between student and institution, student and academics, student and courseware and student and peers. Open distance learning focuses on removing barriers to access learning, flexibility of learning provision, student-centeredness, supporting students and constructing learning programmes with the expectation that students can succeed"

UNISA practices responsible open admission that aims at identifying barriers to higher education and offer appropriate support for students. This has resulted in increasing student numbers exceeding 320 000 in 2011 enrolment and this figure is increasing at a year-on-year average of 9.3% since 2007; see Figure 1 [20]. As of August 2013 the preliminary enrolment was over 389 000 of which in excess of 90% were undergraduate students. UNISA enrolls students from 130 countries globally and over 99% come from Africa. Currently over 1000 qualifications and over 3000 courses are being offered at the institution. The long-term enrolment growth since 2007 remains highest in undergraduate degrees with 73.3% and an average year-on-year growth of 18.3%.



	2007		2008		2009		2010		2011 (Prelim)	
UG Certificates & Diplomas	65 280	27,3%	76 683	29,3%	75 671	28,7%	79 786	27,2%	85 572	26,1%
UG Degrees	133 455	55,8%	141 257	53,9%	144 676	54,9%	164 978	56,2%	188 248	57,4%
PG below Masters	18 480	7,7%	22 214	8,5%	23 562	8,9%	27 224	9,3%	32 194	9,8%
Masters	4 396	1,8%	4 209	1,6%	4 711	1,8%	5 459	1,9%	5 894	1,8%
Doctoral	768	0,3%	778	0,3%	754	0,3%	1 024	0,3%	1 258	0,4%
Occasional	17 001	7,1%	16 786	6,4%	14 185	5,4%	14 966	5,1%	15 013	4,6%

Figure 1: Student enrolments by qualification type, 2007 – 2011 (preliminary)

UNISA's students are diverse from language, location and culture and all these differences need to be taken into consideration when offering online teaching and learning. These varied student profiles coupled with the growing numbers of students have brought about the need for UNISA to move towards the e-learning pedagogy.

3.1. myUnisa Portal

UNISA uses a web portal LMS code-named myUnisa that runs on SAKAI open source educational platform. The LMS provides tools that facilitates the use of email announcements, discussions, learning units, electronic documents, blogs, wikis and self-assessments just to mention a few. MyUnisa and its related tools are used for as an online teaching and learning platform. The students are further allocated a student email account to which email communication from the institution is sent. The students can divert email traffic from this account to their personal email accounts. [21] found that collaborative learning environment through the web portal helped students feel more enthusiastic about learning. Students that discuss learning-related concepts were found to perform better than those that enrolled for traditional classroom lessons [22]. The lecturers will select which of tools to use based on the suitability and relevance to their context and study content. MyUnisa used to deliver tuition content as well as for assignment submissions. The portal is not equipped with summative e-assessment functionality. It faces the same challenges noted in section 2.2 on e-assessment. Therefore, venue based assessments and portfolios are used instead of e-assessments. The portal does not have a dedicated e-learning policy or e-learning information security awareness training for all types of users.

3.2. UNISA Assessment Model

The figures shown in Figure 1 present UNISA with serious logistic challenges when planning and administering traditional venue-based summative assessments for undergraduate students. Finding sufficient venues across the globe to accommodate these rising student numbers is challenging. Hence the drive is to find alternative non-venue based assessment methods, which include portfolios, e-portfolios and e-assessments. Changing the assessment model should have sound pedagogical value for the institution and students, it should not just be for logistical reasons; in other words it must be fit for purpose and address a need. UNISA has adopted the portfolios and e-assessment methods of non-venue based assessments.

The portfolios are used as a summative assessment method that the university uses as an alternative to venue-based examination. Portfolios can be submitted as either online documents or hard copies. The portfolio still leaves the institution vulnerable to student exploitation of the assessment method in terms of getting someone else to do the work for them. Verifying the identity of the creator or author of the portfolio is also a major concern in both portfolio and electronic portfolio (e-portfolio) assessments.

Whether the portfolio was submitted in paper format or online, there is no way of knowing for sure who put it together. Reviewing the author properties of the file might reveal the author name as the owner of the computer or text editor on which the content was created; if the author name is not that of the student who submitted the work, it could be that the student had borrowed or leased the computer on which they completed their portfolio such as using the services of an internet café or using a roommate's laptop. Therefore in the case of portfolios, it is possible that students might plagiarize other students' work and there would be no way of determining the authentic author of the content. E-assessments on the other hand have the advantage of solemnly using the online platform for assessment.

In formative e-assessments, the E-assessments used at Unisa include compiling different questions for the different students if the assessment will not be administered at the same time. These questions would be selected to be assessing the same competencies and skills. Using different questions would be to deter the students from asking the sequence or pattern of answers from their peers who have completed the assessment. The main concern on e-assessments is cheating by candidates. This can be done through accessing external sources of information such as the internet and more seriously one candidate taking the assessment for another candidate, or a candidate stealing another candidate's work and submitting it as their own, i.e. plagiarizing the work of others [23]-[26]. Cheating is not exclusive to e-assessments but it remains an assessment concern in general. These problems can be mitigated by careful design of assessments (such as task-oriented activities). Plagiarism can be mitigated by using online plagiarism detection tools such as Turnitin. Venue-based assessments use numerous authentication methods that can be extended to e-assessment, such as verifying the candidate from their student profile picture taken by the institution at registration. While the venue-based method would be to compare the student card or identity document with the actual person, the e-assessment tool would compare the student picture on their system with the person from the webcam live image of the candidate.

4. E-Learning Security Concerns

There is a great need for securing e-learning systems to ensure that they are not compromised. Securing these systems is also required to gain user confidence in the validity of the online qualification offered. To secure the e-assessment system, the following, per [26] have to be addressed: authenticity of the candidate has to be guaranteed; The e-assessment environment has to be monitored; The e-assessment integrity has to be upheld in order to deter electronic corruption; software glitches have to be avoided by performing periodic system maintenance; user privacy and confidentiality have to be ensured in order to gain user confidence in the system. Ensuring the security of an e-learning system is no easy task, and requires the protection of the content, services and personal data for external and internal users including system administrators, as advocated by [27].

In the e-learning pedagogy, the tuition content is delivered using the internet, intranet or extranet as a medium. [5]. There are traditional security concerns with using the internet as a medium, these stem from the main pillars of information security; confidentiality, integrity and availability (CIA). These concerns by extension need to be addressed in e-learning and e-assessment. Researchers extended these concerns to include authorization, authentication and non-repudiation [5] [24] [27]. Figure 2 illustrates information security principles in the context of the e-learning model.

These principles need to be addressed for the design and implementation of a secure and usable e-learning and assessment system. The security of e-learning platforms has to be considered at system implementation to build controls into it, as well as at the user training phase, to include user e-learning security awareness training. The security awareness training content should be made available to all users of the e-learning system, when the system is introduced to them. This can be in the form of computer-based training or self-help documents including. When the users become aware of the security features on the e-learning system, it could improve their confidence in the system and their willingness to accept and use it [28]. Putting security measures in place for an e-learning system is referred to as e-learning security, and is essential to establish e-learning as a trusted tuition medium [28]. The security concerns as identified in literature which need to be addressed in e-learning and e-assessment are denoted by the acronym CIANAP and each element of the CIANAP is explained in the following paragraphs.

***C**onfidentiality* - E-learning material need to be made available only to authorized users, the system should provide unspoofable security mechanisms. Confidentiality protects against unauthorized access and distribution of an institution's learning material as these need to be made available to enrolled students. Confidentiality is particularly important for e-assessment as timing of the assessment release is of vital importance and only authorized students should have access to the e-assessment for a specified period of time. The confidentiality also ensures that the user data is kept confidential in transmission and storage as highlighted by [5] [27] [31]; such data include personal information and assessment results.

***I**ntegrity* - Integrity addresses the need for the information not to be modified by unauthorized users, ensuring that the information integrity is preserved. Only authorized users of the e-learning system should be allowed to view, modify or delete the learning material. The system should allocate appropriate rights to students and facilitators. Modification of e-learning material should be performed by legitimate and authorized users [5] [27]. Such information includes learning material and assessment results. The integrity concern is also considered from the perspective of conducting summative assessments where students are assessed remotely; because of the lack of adequate electronic mechanisms to identify the assessment candidate. Therefore venue based e-assessments are used where the candidate identities are manually verified.

***A**vailability* – Availability is concerned with the system resources accessible to authorized users whenever they need to access them [32]. One of the main draw cards of e-learning model is its availability twenty-four seven. The availability of e-learning web portal is important and the system should be protected from availability security threats such as denial of service (DOS) and distributed DOS (DDOS) [33]. UNISA have students from all over the globe, to accommodate different time zones, the system should allow students to log on to the system twenty four hours a day. ODL students often partake studying and working at the same time, hence continuous system availability facilitates easier learning and allows students a flexible study and work schedule. The availability aspect extends to the system availability when the students need to access it. There are chances that the system could become overloaded during peak usage times. The system could also be unavailable during its maintenance and update periods. Therefore, prior communication of scheduled system interruptions is sent to the students so that they are aware and can prepare for the system downtime.

***N**on-repudiation* - Non-repudiation ensures that a system user does not refute actions they performed on the system [32]. An e-learning system should provide integrity of the source of actions and make sure messages or actions are not modified in transit between the communicating parties [5] [24] [27] [31]. Students who have submitted assessments for grading should receive confirmation in the form of email or SMS with a timestamp that cannot be refuted at a later date by the system.

***A**uthentication* - Authentication is specifically concerned with ensuring the identities of the parties involved in a communication, thus, avoiding man-in-the-middle and identity theft attacks. In e-learning, this usually involves a user and the e-learning server, so as to avoid leakage of confidential information to the wrong parties. This is of particular importance to e-assessments where the identity of a remote user is an integral part of the whole model [25]. Violation of authenticity brings into question the quality of qualification being offered online and ultimately impacts the reputation of the institution offering the qualification. Central to authentication is the implementation of access control mechanisms that are trustworthy and reliable to appropriately grant access rights [24]. This problem has results in a number of studies attempting to find a solution to positively identifying the assessment candidate, when assessment is conducted in an unsupervised environment [23]-[26] [29]. For instance, [30] proposed a safe and secure solution for remote supervision of a video based examination with easily available hardware and software tools.

***P**rivacy* – Privacy is concerned about the collected information being used only for the intended purpose. In the context of e-learning privacy ensures a learner's ability to maintain a "personal space" within which the learner can control the conditions under which personal information is shared with others [35]. This information includes students' personal information and contact details, this includes collected identification information such as personal information, login details and biometric information [34].

Violations include using contact information for non-academic purposes. Usually the importance of privacy is recognized after it has been breached.

4.1. Proposed Framework for E-learning Security

Figure 2 illustrates components of the CIANAP framework for e-learning security. The Figure also highlights the assets to be protected, threat sources and available protection mechanisms. The identification of critical assets and classifying them to categorize elements that provide critical functionality is the first step to protecting these assets. Threat sources are potential attack sources that can originate an attack. Protection mechanisms list the technologies that can provide protection to counter threats to the assets.

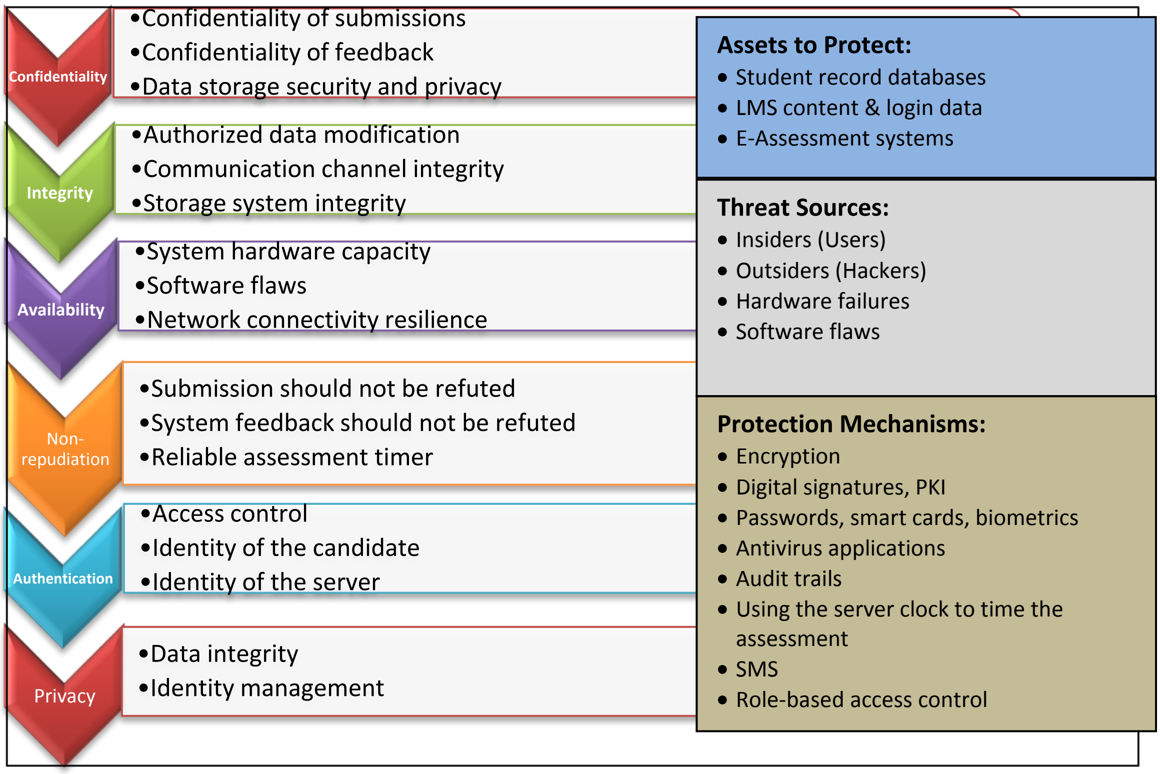


Figure 2: CIANAP E-learning Security Framework

Confidentiality can be ensured through encryption of the communication channels and storage devices. Role based access control also ensures confidentiality by ensuring that users of the e-learning system have appropriate access rights to e-learning resources. Attacks on confidentiality of the e-learning system usually do not alter the e-learning content, but only affect the dissemination of this content and learners' personal data. Confidentiality attacks may be used as a first step in availability or integrity attacks, as where the attacker obtains confidential passwords by defeating encryption or simply by password guessing [33].

Integrity attacks can be countered by unspoofable mechanisms that verify information and communication sources. Commonly used integrity checks are password-based attempt to actively modify or destroy information in the e-learning site without proper authorization. More secure systems use multiple integrity checks, such as combinations of password and token-based mechanism or additional channels such as SMS (Short Message Service) security mechanism to ensure that on the registered users are allowed to access and modify or update the system data. The student would first be authenticated with a user id and password, and then a special password or personal identification number (PIN) would be sent to the student's registered mobile number in the form of an SMS. Biometric mechanisms are also becoming popular for securing critical assets. Audit trails ensure integrity of the stored data and information, by keeping track of all changes made to the system databases and recording the user who effected such changes.

Antivirus and firewall systems are used to protect against *availability* attacks. These include systems such as intrusion detection and prevention systems, DoS Defense System (DDS) and specialized routers or switches that provide such functionality. Ultimately system interruptions and downtime should be reduced or eliminated especially that which originates from a malicious attack.

To address *non-repudiation*, audit trails, digital signatures and PKI (public key infrastructure) encryption should be put in place. There are a number of mechanisms available for ensuring non-repudiation, these include trusted third parties such as certificate authorities (CA) that can issue a user with non-refutable certificates. Digital certificates and digital signatures use PKI mechanisms to ensure non-repudiation of digital transactions. [2] proposed an application layer non-repudiation multi-level signature-based system, which features a biometric scheme to create digital IDs in a mobile learning environment. Digital signatures and PKI can also be used for encryption purposes.

Authentication attacks occur when an attacker masquerades as a legitimate end-user using correct credentials acquired illegally. These attacks can be addressed by requiring re-authentication at specified time intervals and designing a system that requires multiple authentication mechanisms that use different channels of communication. An example is the use of a combination of password and one time password (OTP) received as SMS tokens. Such an attack can be a launch-pad of numerous other attacks on confidentiality, integrity and availability [33]. User education and training is needed to provide awareness on the importance of protecting confidential system access credentials.

Privacy attacks usually results from the security breach on the assets by a third party that stores personal information of individuals and passes it on to other parties for their own use. The use of such leaked information violates the privacy of users. Privacy can be protected by providing confidentiality, integrity and availability on the collected and stored personal information. It is also important to educate those employees that handle individuals' personal information on how to protect it from accidental leakage. For instance, policies must be in place that prohibit such practices as connecting external devices (e.g. memory sticks) to computers that store sensitive data or storing personal data on memory sticks that can easily get misplaced or stolen. Organizations that collect personal data can also breach users' privacy without any leakage taking place, by using the data for other purposes other than the intended purposes as disclosed to those who provided the data.
The success of e-learning and e-assessment in terms of security depends on the implementation of technologies that can provide sufficient security to the protected assets. Besides technology it also largely depends on the participating human users taking responsibility and being accountable. Accountability is essential to maintain a good working relationship between the e-learning institution and its students. Both the student and the institution (including employees) have to be held accountable for their conduct on the e-learning platforms. This means that the actions performed in one's profile would have to directly be associated with the user and therefore this would be expected to encourage the users to protect their profiles and act with integrity. Consequently the accountability factor would be placing the security responsibility in the hands of the users and empowering them to secure the e-learning system. Acceptable use policies should be presented to the users at first use to ensure compliance to what is acceptable behaviour when using the e-learning system. At the center of all this is user awareness through education and training to alert the users to the potential risks when using e-leaning system and how to respond to the risks. This should include enforcing the users to set only strong passwords and not disclose their user credentials to anyone, including the system administrators.

5. Findings and Conclusion

The successful implementation of e-learning and e-assessment systems in a large ODL institution like UNISA need careful planning that involves all stakeholders as their core business would be reliant on the successful implementation and adoption of the e-learning platforms. Therefore the institution should ensure that there are software and hardware security controls in place. Stand-alone, formal policies on e-learning systems and their use should be in place by the providers of e-learning, to serve as governance controls. The policies should address various aspects of the e-learning model including security. The security aspect of the policies should cover the CIANAP of e-learning as proposed in this study. There should also be ongoing user security awareness training that cover the user conduct and use of the e-learning system. The adoption of online assessment should be done gradually with milestones and pilot module rollouts for testing the volumes and stability of the platform to ensure the *availability* of the e-learning system. Large scale rollouts are a huge risk for an institution the size of UNISA. Further research could investigate the effectiveness of the recommended controls for e-learning and e-assessment platforms. The authors recommend that further research be conducted to test the CIANAP framework's impact on the security and success of online summative assessments.

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An analysis of ICT infrastructure requirements for e-learning in Higher Education: A case of Walter Sisulu University

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Abstract

E-learning researchers have explained the success of e-learning based on approximately 4 main pillars i.e. adequate ICT infrastructure, supporting e-learning resources, highly skilled technical staff and enabling ICT policies. These pillars are all critical in ensuring effective e-learning usage. In Higher Education (HE) e-learning has improved learning services and enhanced students' capacity by improving the quality of teaching and learning. This paper focuses on explaining the components of e-learning i.e. proper ICT infrastructure. The authors focused on ICT infrastructure as it forms the basis for adopting the other pillars. In this paper Walter Sisulu University (WSU) is used as a case study. Qualitative research techniques i.e. interviews, observations and document review were employed. All the interviews were recorded using a voice recorder. Data translation of interviews and Excel were used for data analysis. Within the WSU community, the authors targeted the ICT department, lecturers and Centre for Learning and Teaching Development (CLTD) department. Results have shown that setting up a well-connected ICT infrastructure could ensure that Higher Education institutions such as WSU benefit from e-learning. Current observations within WSU have shown that there is poor ICT infrastructure to support e-learning. The paper highlights the key components of the ICT framework. An analysis of the WSU community views on ICT infrastructure requirements for e-learning was done. This was enhanced by comparing the results of the interviews to existing literature. The authors explain an overview of ICT infrastructure requirements. These requirements are meant to improve the quality of learning at WSU and can be implemented in other HE institutions within South Africa.

Keywords: *e-learning, ICT infrastructure, ICTs, ICT infrastructure analysis.*

1. Introduction

E-learning has become a new paradigm and a new philosophy in the education sector that moves learning from a traditional form to digital literacy. Some authors state that e-learning transforms learning by heightening access to HE, reducing cost of delivery, and enriching the quality of education [1,2]. Largely, e-learning expertise signifies a breakthrough where digital divide can be lessened and ensures faster and high developmental trends [3]. Furthermore, e-learning has been said to be amongst knowledge contest which developmental universities must implement to improve the learning environment [4]. Similarly, the progress of technology immersion in all aspects of life has left HE no choice but to respond to the pressure and place technology at the centre of their core business which is teaching and learning [5].

This paper reviews the current literature on e-learning to mine the position of e-learning usage in HE. It further explores the relevant literature on e-learning ICT infrastructure requirements to see if they relate to the ones investigated by this paper. Furthermore, it seeks to draw solutions on the current literature which can assist in developing an ICT infrastructure framework for e-learning usage that can be adopted by Walter Sisulu University: College Street Site. The authors are lecturers at WSU and this paper is motivated by the authors' observations and experiences that WSU is not fully utilising e-learning despite the potential benefits it brings. Furthermore, the authors' interests are in the importance of e-learning and its benefits. This paper therefore investigates an ICT Infrastructure framework for the use of e-learning that can be used in WSU and perhaps in other HEIs as well. The paper explains part of the results which were obtained during the interviews conducted. The paper also forms part of the e-learning project that has been conducted at WSU. However, the results given in this paper are only based on one particular site of WSU. And these results were complete to understand the WSU community – College Street Site's views on ICT infrastructure requirements for e-learning. The research questions addressed in this paper are explained below:

1.1. Research Question

How best can ICT infrastructure requirements be determined and analysed to enable e-learning usage at WSU?

Sub-Questions

In attempting to answer the main research question the following sub questions were formulated:

a) To what extent do different ICT infrastructure requirements affect e-learning usage and what are the barriers to e-learning usage at WSU?

In this sub-question, the ICT infrastructure requirements were discussed and challenges of e-learning were identified. The aim of this sub-question was to provide a better understanding of the cause of under-utilisation of e-learning applications in other universities especially those that have started using e-learning. Furthermore, this sub-question seeks to discover if these e-learning issues are applicable to WSU.

b) Which factors influence the success of e-learning usage and how does the current state of ICT infrastructure at WSU encourage or hinder e-learning usage?

In these sub-questions the success factors for effective usage of e-learning are investigated and evaluated. The aim of the sub-questions was to see how best these success factors can be applicable to support usage of e-learning and to assess the current ICT infrastructural support for use of e-learning in WSU?

1.2. Overview of E-learning at WSU: College Street site

WSU is a developmental university which already adopted e-learning, but it is still struggling to fully utilise the e-learning platforms and enjoy e-learning benefits.

Current situation at WSU: College Street

From the observations and experience of the authors the difficulties that WSU is facing include unstable internet access, lack of wireless connectivity, shortage of computers in the labs, lack of e-learning awareness among some staff and students, and shortage of technical ICT support staff. The current student to computer ratio at WSU is currently 1:9. This affects the student access to ICT resources. The other challenge is the unavailability of 'Walk In Walk Out' (WIWO) computer laboratories limiting student access to the computers outside lecture rooms.

Learning Management System (LMS) that is used in WSU

The LMS that is used at WSU is Blackboard – Learn 9.0 referred to as WiseUp which is actually used to upload students' work such as assignments, notes, students' collaborations, online testing and online evaluations. But the problem again is the poor ICT infrastructure which makes it difficult to fully utilise e-learning since failure in network would require an alternative plan. As a result, some staff members are discouraged to use e-learning for teaching and prefer to use old methods of teaching due to WiseUp instability. The WiseUp server which houses the e-learning material is centrally located. This again poses a challenge since WSU is a multi-campus university and accessing this server means network links to connect to this server should always be up and running otherwise failure to connect causes this server to be inaccessible. The unstable networks make it difficult for all the WSU campuses to access the e-learning server all the time.

However, WSU is undergoing initiatives to improve the situation as a part of Turn-around strategy and SANREN project [6]. For instance, WSU has improved bandwidth capacity from 100MBps to 1 gig which is massive for downloading of multi-media files. Some of these projects are still a work in progress and are scheduled to finish in December 2014. Despite the current development at WSU there is still a long way to go in terms of provision of satisfactory e-learning services. The authors used a couple of research techniques to gain an in-depth understanding of the WSU community. This was through employing the methods explained in the next section.

2. Research Methodology

To fulfil the objectives of the paper, a couple of research methods were used in this paper. These are explained in the following sections.

2.1. Research Paradigm

The study explained in this paper followed a qualitative paradigm research technique. Qualitative approach seeks to understand people's views, belief system and practices [7]. Using qualitative paradigm was therefore appropriate to elicit the different views that the WSU community has, pertaining to their e-learning experience.

2.2. Data Collection Methods

The case study was used as the main research method in this paper, where the case is WSU College Street delivery site, and the case study relates to proposing an ICT infrastructure framework to support e-learning usage at WSU. Within a case study, multiple methods can be employed to strengthen its findings [8]. This approach is called triangulation. Thus, this paper used triangulation approach on the basis that it produces better conclusions since using one source of evidence can be insufficient to give a comprehensive perspective on the problem being investigated [7]. Again, using triangulation is good for checking and verifying consistency in findings from different sources [8] and to balance out the bias of individuals [9]. Again, literature review was used in order to justify the problem being investigated and how e-learning has been approached in other institutions. In addition to this, document review was conducted to look at historical information; such as ICT budgets, plans etc. for WSU.

A random sample of 5 lecturers from two departments was interviewed on the basis of their knowledge about e-learning. However, only a sample of the results was used to construct Table 1 and Figure 1, which are shown later in the paper i.e. a random sample of a few respondents' feedback. The semi-structured, open ended interviews were administered to these lecturers since they are key people within WSU, to ask about their e-learning challenges and also recommendations. Similarly, the ICT manager was also interviewed face-to-face to elicit the challenges pertaining to ICT infrastructure support for e-learning and possibly identify requirements for satisfactory ICT infrastructure in WSU. All interviews were recorded using voice recorder and transcribed and key comments were extracted for data analysis. Furthermore, the CLTD manager was engaged on telephonic interview to elicit the plans regarding the progress of an e-learning platform as well as future tactics to assist the usage of e-learning in WSU. Questionnaires were developed with the aim of identifying the challenges involved in the diffusion of e-learning with regards to existing ICT infrastructure at WSU. The data obtained from the questionnaires was grouped according to the research questions of this paper. The findings of the collected data were linked back to the current literature in order to perform an analysis. Therefore, the analysis of the ICT infrastructure requirements was done based on the WSU community views and the current literature on e-learning.

3. Analysis of e-learning based on literature

Many researchers have defined the term e-learning in several ways; however this paper considers a few of these definitions. For example, e-learning has been defined as learning that is imparted through use of ICTs [1, 2]. In a bigger aspect e-learning integrates group or individual learning activities whether online or offline, synchronously or asynchronously over networks or personal computers and other electronic media [10]. Moreover, e-learning has been acknowledged to cultivate experiences that enlighten populations through the use of internet and technologies [11]. However, the rapid developments in technology make e-learning an on-going objective since newer developments give room to more learning options [12].

Despite these benefits of e-learning, there are challenges to effective diffusion of e-learning in some Higher Education Institutions (HEIs). Perhaps all these challenges need to be scrutinised separately for e-learning to be effective, however at the core of e-learning practice is ICT infrastructure and that ICT infrastructure forms the basis for all e-learning practices [13]. Therefore, reliable ICT infrastructure is critical for a successful e-learning environment; and if properly implemented it will reduce costs that are linked to the delivery of teaching and learning [14]. This implies that there is a need to invest on ICT infrastructure to enable e-learning implementation. Similarly, learning and ICTs should be linked together, where collapse to any of them, would greatly disturb the educational value of e-learning [15]. Even though e-learning has potential that promises to benefit HE, it still faces challenges or constraints [10]. These challenges hinder the effective implementation and usage of e-learning in HE and are studied in the next section.

3.1. Challenges of e-learning implementation in HE

Many studies have shown that challenges facing HEIs to fully utilise e-learning are characterised by lack of funds, poor e-learning planning procedures, resistance from other stakeholders, and lack of engagement with other stakeholders. These stakeholders in e-learning are said to be students, lecturers, employers, HEIs, government, technology providers and content providers [16]. On the other hand adopting learning technologies impose challenges, that when preparing for an e-learning class, lecturers must also develop contingency plans incase of technical failures [17].

Rapid changes in technology also make it difficult to provide effective e-learning solutions for some HEIs [18]. These technological changes require frequent software updates and well trained supporting staff, so it might be difficult for HEIs to keep up due to cost implications. On the other hand, spreading out the implementation from a few adopters has been identified as another major challenge in making technology-supported teaching a main function [1, 19].

The other challenge facing e-learning in HE is lack of ICT resources i.e. insufficient computers in the computer labs. Some studies have shown that challenges regarding usage of e-learning in HEIs are shortage of ICT support personnel, insufficient availability of hardware and software, slow internet connectivity, illiteracy among staff and students and unreliable sources of electrical power [20].

Also some of these challenges were identified at WSU, when the respondents were asked about the challenges they experience regarding their e-learning usage. The respondents identified issues such as *"Network always down*", "*lack of e-learning training*", "*Lack of connectivity in some computer labs*".
It is evident that e-learning implementation in HE is complex. However, many e-learning studies recommended some solutions to e-learning challenges and these possible solutions are discussed below.

3.2. Possible solutions to e-learning challenges in HE

Recent studies on e-learning have also indicated that alignment and adapting to market and technological change is mandatory for HEIs to heighten their global competitiveness[4, 21]. However, limited ICT budgets impose even more constraints for HEIs to adapt to these technological changes. Still, HEIs must make bold efforts and even the poorest institution cannot afford to overlook the holistic potential of e-learning [22]. Alternatively, limited ICT budgets can be addressed by adopting open source software (OSS) since it offers an opportunity to lower the costs of software by eliminating software license fees, thus freeing more budgets to manage the software [23]. The availability of the source code in OSS gives room to customize it and also identify some shortfalls that can be resolved by a third party and bring about reliability, performance and security [24].

Additionally, interview respondents when asked about what can be done to solve e-learning challenges at WSU, some replied: "*Holistic approach at institutional level, to engage all lecturers and students to use e-learning*". Additionally, all respondents unanimously identified "*need to promote e-learning*" and "*bigger budgets*".

3.3. ICT infrastructure requirements for e-learning based on literature

Following current literature on e-learning usage in HE, the authors have discovered some of the ICT infrastructure requirements that have been studied by other researchers. Unquestionably, ICT has become critical to knowledge exchange, diffusion, and application in so many ways as a result future growth in HE revolves around ICT [25]. One of the obvious contributions of ICTs is to provide easier and almost prompt access to data and information in a digital format that allows manipulations that sometimes would not be possible in any other format [2]. ICT infrastructure in the context of this paper is the mixture of networks, hardware and software as well as communication apparatus, which enable the handling of information, dissemination and knowledge acquisition.

The development of reliable ICT infrastructure is likely to support the provision of e-learning and business objectives. For e-learning to be implemented in any institution, an ICT infrastructure is a basic prerequisite [13]. However, in some developing countries ICT infrastructure is still facing major challenges in successful deployment of e-learning [16]. Technical problems within an e-learning environment often arise in one of three basic elements, viz. hardware, software and bandwidth volume [16]. Such problems intensely disturb the process of e-learning implementation [26]. Adequate ICT infrastructure includes computer facilities, connectivity, technical support and reliable source of energy [13]. Therefore, an accessible ICT infrastructure with capacity and technical support is necessary for the flow of e-learning.

In this paper different components of ICT infrastructure are identified and discussed in detail. Many studies on e-learning have thrown some light regarding setting up and maintenance of a satisfactory ICT infrastructure i.e.

- Consistent, high-speed bandwidth and access to network and web including 'out of class' access with the use of mobile technologies [27].
- Provision of ample computer resources. Although some students have means to acquire their computer resources, it is critical to ensure that all students gain equal access to computer resources [25].
- Plan of inclusion: where e-learning is promoted and lecturers and students are encouraged to participate in e-learning to enhance the learning practise [1].

4. ICT infrastructure requirements: (based on the interviews at WSU)

Respondents assessed were staff members, CLTD and ICT technical staff. All respondent unanimously identified "*need for training*" and "*network upgrade*" as significant requirements to support e-learning at WSU. When ICT manager was asked about "What are requirements for a proper ICT infrastructure to support e-learning?", he identified, "*Need to install separate e-learning servers in respective campuses to support e-learning needs*", "*the need to deploy wireless infrastructure"* i.e. Wi-Fi in student residences and libraries. Table 1 was used to summarise the views of WSU community. The words ***Resp 1-6,*** refers to randomly selected respondents. The mark ***X*** indicates whether the respondent was considering the corresponding item as a requirement. The classification of the category requirement was done according to the authors' discretion on the available ICT requirements.

4.1. Summary of interviews

Table 1: Summary of the results from the WSU community respondents

ICT infrastructure Requirement	**WSU Community (lecturers, ICT manager & CLTD representative)**					
Category of requirement	**Resp 1**	**Resp 2**	**Resp 3**	**Resp 4**	**Resp 5**	**Resp 6**
Proper Network support	X		X	X	X	X
E-learning training & awareness	X	X	X	X	X	X
Decentralised-learning servers	X		X			
Engagement of stakeholders	X			X	X	
Financial budget	X		X		X	X

4.2. Analysis of current ICT requirements based on literature vs. WSU community

Current literature has given some valuable insights on some requirements for successful e-learning usage in HE. Some of these requirements as mentioned by Arabasz & Baker (2003) include proper ICT infrastructure, well equipped computer laboratories and well-trained ICT supporting staff [18]. Moreover, encouraging use of educational technologies in teaching and learning is vital in HEIs [1]. Therefore, the technical infrastructure should be satisfactory in order for e-learning to be effective; otherwise the likelihood of collapse is high.

Furthermore, understanding what benefits e-learning brings into their students' learning practise is likely to influence the full adoption of e-learning by academic staff [1]. Therefore, HEIs which strive to get e-learning right are likely to be in a good competitive standing, universally [4].

Similarly, following the case study and findings in WSU: College Street, poor network has been identified as the key contributing factor to non-adoption of e-learning in WSU: College street site. Also all the respondents unanimously identified "lack of training" as a challenge, this means that academic staff members do not necessarily understand the significance of using e-learning as a teaching tool.

The rest of the views are explained in Figure 1, these were built from Table 1:

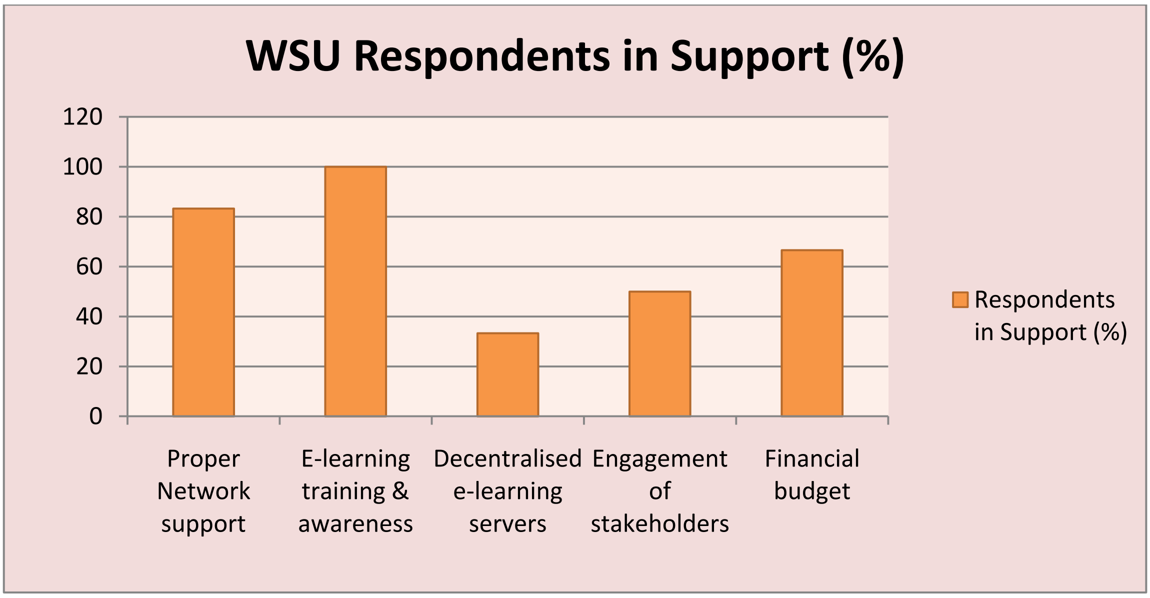

Figure 1: WSU Community on ICT infrastructure requirements

Therefore e-learning administrators need to device strategic ways to promote the use of e-learning in WSU. In contrary, those already engaging in different e-learning programmes and are fully aware of e-learning benefits, expressed concerns with regards to the poor network and Blackboard server's down time. One of the respondents said:-

"Network is always down; sometimes I upload all the material, when the students have to access it, the server is down for days. This situation has forced me to go back to old ways of teaching".

This clearly indicates that lack of ICT infrastructure, among other reasons, influences the non-adoption of e-learning in WSU. Also based on the interviews "*bigger budgets*", "*involvement of all stakeholders*", "*e-learning training*" have also been identified to be requirements to e-learning usage. Therefore, it is evident that within the ICT infrastructure requirements for e-learning, there are other important components that should be in place. These components include stakeholders' engagement and commitment, well-trained e-learning users and proper budget. There is a relationship between the current literature requirements and what the WSU community identified as requirements for e-learning.

5. Conclusion

The paper focused on identifying the ICT infrastructure requirements to support e-learning. These requirements are available in the current literature on e-learning. However, the important contribution of this paper was to get the views of the WSU community on what could be the requirements to improve the current e-learning environment at WSU. This paper reports the ICT infrastructure requirements based on the current findings and is part of the complete research which is currently underway to develop an ICT infrastructure of e-learning at WSU. The findings from the interviews show that e-learning awareness and training are essential at WSU for the institution to benefit from the e-learning benefits. The findings also show that the current ICT infrastructure, reportedly as slow and unreliable without full access to the WSU community, cannot fully sustain and support e-learning. These challenges which are currently facing WSU contribute to poor usage of e-learning and were useful in determining the e-learning requirements. Besides the proper ICT requirements, findings also indicated the need for stakeholders' commitment, and a well-structured financial budget to support e-learning is essential in implementing and sustaining e-learning. The findings were very similar to the currently available e-learning requirements on the literature. However, it was essential to consider the requirements of the WSU community, in developing the ICT infrastructure framework for the University, which is the main project undertaken by the authors.

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e-Learning in a developing context: a South African University of Technology case study

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Abstract

Rapid advances in ICT and relatively easy access to the Internet are reshaping our education by providing new learning environments and new ways of teaching, learning and assessing in higher education. While most higher education institutions in the developed world have already embarked on encompassing these newer, modern technologies into their classroom environments, universities in the developing world are lagging behind in integrating these technologies into their core academic functions. This study posits that a deeper understanding of three important aspects of the e-learning phenomenon, viz., access, use and perceptions, are pre-requisites for the planning and eventual integration and adoption of e-learning technologies in a developing context. Consequently, the study examines ICT access and use levels among 120 university students and their perceptions about the use of the Internet, Web 2.0 and social networking tools for academic purposes. The primary data collection instrument was an online survey questionnaire, which was followed by focus group meetings among 2 select groups of study participants. Consequently, the paper reports on the emergent trends arising out of the statistical analysis of the survey data, which are supported by insights gained from the analysis of the qualitative data collected during the focus group meetings. Indeed, a deeper understanding of the issues underpinning student access and use is required, if we are to take advantage of the potential held by new and emerging ICT tools, as we progress rapidly into the information and knowledge era.

Keywords: *e-Learning, Higher Education, ICT Access, ICT use, Use surveys, Web 2.0.*

1. Introduction

Rapid advances in ICT and relatively easy access to the Internet and the World Wide Web are reshaping our education by providing new learning environments and new ways of teaching, learning and assessing in higher education [1]. Web 2.0 and social networking technologies continue to present new opportunities for enhancing the learning experience of students [2]. In addition, the proliferation of student ownership of smart mobile devices and the establishment of campus-wide wireless networks are increasingly enabling new and interesting methods of encouraging students to learn [3].

While the adoption of e-learning technologies at higher education institutions in the developed world are generally at an advanced stage, the integration of such technologies into the teaching and learning functions in the developing world has been lagging behind [4] [2]. In particular, “ICTs in higher education” is a new and developing domain of enquiry in South Africa and no unanimity in the conceptualization, visualization or utilization of ICTs at institutional level exists [5]. Evidently, many crucial aspects have still to be defined, and many important details of ICT access and use are still to be filled in [5]. This study is a contribution towards that end. The primary focus of this study was to investigate student access to, use of and perceptions about an array of technologies and technology-based tools. Specifically, mobile technologies and web 2.0 tools formed a major focus of the study.

2. Background

ICTs have been known to improve every aspect of university life, from registration to office administration, from teaching and learning to assessment, and from communication to research collaboration. The rapid diffusion of computers and Internet use has been a fixture of the global landscape over the past 2 decades; nonetheless, rates of technology use still differ markedly across countries [6]. The importance of ICT diffusion in developing countries to economic advancement has been stressed in the policy arena and previous literature [7]. For developed economies, the literature is fairly well developed, while the implications for developing countries are only now being explored in a systematic fashion [6]. Some of the most significant contributing factors to the poor usage in developing countries are the high ICT access costs, lack of basic skills, and an insufficiently developed ICT infrastructure [8].

Moreover, there is a paucity of research about ICT access and use in higher education in South Africa [9]. While there has been some studies focused on e-learning initiatives in South Africa, most of the research seem to take the form of specific technologies applied to local case studies rather than meso- or macro-level investigations [5]. Given the many unknowns about the use of ICT in higher education in South Africa, there is a lack of a clear direction on where e-learning is headed and how university staff can plan for its effective implementation in their institutions.

The most common and accessible form of an ICT device is considered to be the mobile phone. Mobile phones are being used for common tasks previously only possible using computers, such as browsing the Web, sending and receiving e-mails, instant messaging and chat, downloading applications as well as for entertainment purposes [10]. For a student from a developing country, mobile technology is seen to be more cost efficient than other technologies which are necessary for eLearning. Mobile technology represents an important avenue by which we can reduce the digital gap in a society where access to knowledge and information is increasingly important [11] [12]. Mobile phones create an environment where learner-centred learning becomes possible by enabling students to customise and adapt the access to information in order to meet their own educational goals and needs [10].

The Mangosuthu University of Technology (MUT) is one of five universities in KwaZulu-Natal (KZN), and is located in the Province with the second highest population in the country which is about 21% of the total population of South Africa. The University is located in Umlazi Township which is also the biggest township in the Province. The main language spoken in the Province and also at MUT is isiZulu, followed by English and Afrikaans. KwaZulu-Natal has the second largest regional economy in the country, contributing around 16.5% towards the GDP of South Africa [13].

As part of the national goal of transforming higher education, the government in 2007 changed the designation of MUT from a technikon to university of technology, making it the youngest UoT in the country. As a result, MUT as a university of technology has been required to reposition its purpose and role within the higher education landscape [14]. It presently provides undergraduate professional and vocational education to students from KwaZulu-Natal, other provinces and from neighbouring SADC countries. It has a single campus accommodating around 10 000 students enrolled for a limited range of mainly undergraduate degree and diploma programmes mainly in the fields of science, engineering, and technology, and in business and management.

3. Research questions

The first aim was to empirically document the degree to which students at a developing University of Technology access and use new technologies. Secondly, the impact of new and emerging technologies on the teaching and learning activities and students' perceptions of and attitudes towards the usefulness of such technologies were investigated. In particular, the following specific and practically achievable sub-goals were identified at the commencement of the study:

(1) What technologies do students have access to and what is the nature and extent of such access?
(2) What patterns and trends exist among student use of such technologies?
(3) What do students feel about the use of the Internet, Web 2.0 and social networking tools for academic purposes?

This study posits that a deeper understanding of the above three aspects will significantly contribute to the fast integration and adoption of e-learning technologies in a developing context.

4. Methodology

4.1. Research Design

The nature of the research questions underpinning this study required the collection and analysis of both quantitative and qualitative data. Consequently, a two-phase sequential mixed methods design aligned with the theoretical motivations provided by Creswell and Plano Clark [15] was selected for this study. Mixed methods research is defined as the class of research where the researcher mixes or combines quantitative and qualitative research techniques, methods, approaches, concepts or language into a single study [16], and its basic premise is that the combination provides a better understanding of research problems than either approach by itself [17]. In the first phase, mainly quantitative data was collected through an online survey questionnaire. The second phase consisted of two focus group meetings during which mainly qualitative data was collected. The main objective of the focus group meetings was to verify some of the findings and to gain a deeper understanding of the issues underpinning student access to, use of and perceptions about e-learning technologies.

4.2. Research instruments

4.2.1. Survey questionnaire

The primary research instrument in this study was an online survey questionnaire. The questions were developed after a preliminary investigation into potential indicators from the literature and with informal conversations with potential study participants. The online questionnaire was pilot tested among a select group of students under laboratory conditions. A discussion with the pilot test participants followed, during which each question was interrogated to establish whether their interpretation of the question was aligned to the intended meaning. As a result, 3 questions were re-phrased (to the satisfaction of the pilot study participants) to eliminate ambiguity and additional options were provided for two other questions. The final questionnaire contained 51 data items grouped into 5 sections as follows: (A) Demographic details, (B) ICT access and use, (C) Mobile Technology access and use, (D) Social Networking, and (E) Teaching and learning technologies. The questionnaire was available in English only.

4.2.2. Focus group meetings

In order to verify some of the findings and to gain a deeper understanding of the trends and patterns which emerged during the analysis of the quantitative data, focus group meetings with students were convened. A questions framework was developed during the analysis of the survey responses and was used to guide the discussion during the focus groups. 18 students responded to the call to participate in the focus groups. The participants were divided into two groups according to their area of specialisation and a focus meeting was convened for each group. Each focus group meeting lasted for about 45 minutes.

4. 3. Sample

The study participants were drawn from final year Information Technology students at the Mangosuthu University of Technology. While it is recognized that the sample may not necessarily be representative of the entire student population at a developing University of Technology, it is suggested that the quantitative data represents a snapshot of the current circumstances of a particular cohort of the student population and hence, generalisations to a limited extent may be possible. This assertion is underpinned by the similarity of the characteristics of the sample to that of the general student population. In other words, the sample is clearly a subset of the sampling frame, with respect to the characteristics such as schooling background, personal experiences, economic status, and age group.

Moreover, the selection of IT students was motivated by a basic assumption that those who work most closely with ICTs are more likely to be using the most up to date technologies, which will place them in the upper end (best) of the spectrum of early adopters of technologies for teaching and learning [3]. Notwithstanding the foregoing arguments, it is posited that valuable lessons may be learnt from the analysis of the data collected during this study, contributing to developing a deeper understanding of the e-learning experience among students at a developing university – an explicit aim of this study.

4. 4. Data collection procedures

Students were e-mailed the URL to the survey questionnaire and were requested to participate in the research. As a follow-up, students were reminded of the call for participation in the research project during their formal lectures. The online questionnaire remained active during the first two weeks in April 2013. The purpose and nature of the research project, the voluntary and anonymous nature of participation in the study, assurances of confidentiality of all collected data, and procedures to terminate participation during the survey were provided in the introduction to the online survey. These ethical aspects were also highlighted in the body of the e-mail sent to the students. A Livescribe Smartpen was used to take researcher notes during the focus group sessions and a separate audio recording of the proceedings was made. The recordings commenced after the permission of the participants were obtained.

4. 5. Data analysis techniques

The quantitative data collected through the survey instrument were analysed using the SPSS application software. Frequencies and descriptive statistics were derived from the captured data and the results were examined. Cumulative percentages produced during the analysis aided in interpreting the results according to groups or clusters. Cross tabulations were used to categorise responses on the basis of more than one variable at a time. Qualitative analysis of the audio and textual data gathered during the focus group meetings were carried out manually using thematic analysis techniques and the results and interpretation thereof has been incorporated in the section that follows.

5. Analysis of findings and discussion

This section presents the findings from the analysis of the survey responses and the discussion is supplemented with explanations and responses gathered during the focus group meetings. Recommendations and suggestions for the implementation of e-learning technologies in a developing context are also incorporated into the text that follows.

5. 1. Profile of respondents

Study participants were registered for their final year of study towards the National Diploma in Information Technology. 120 respondents provided usable data for this study. Table 1 depicts the demographic profile of the respondents. There was slightly more females (57%) than males (43%) in the total student sample. Only 10 students indicated that they were older than 24 years, while the remainder (n=110, 91.7%) were in the 18 to 24 year age group. The vast majority (n=87, 72.5%) of students live in University residences during the academic term. These characteristics of the sample closely align to the general student population at the university [18]. The department of ICT offers two streams (specialisation areas) within the IT diploma qualification, which students choose at the commencement of their second year of study - 51 (42.5%) students in the sample were registered for the software development specialization, while 69 (57.5%) were registered for the communication networks stream.

Table 1. Demographic profile of respondents (N=120)

Item	Descriptive options	Frequency	Percent
Gender	Female	68	56.7
	Male	52	43.3
Age	18-24 years	110	91.7
	More than 24 years	10	8.3
Place of Residence	At Home	28	23.3
	University Residence	87	72.5
	Other	5	4.2
Diploma Specialisation	Communication Networks	69	57.5
	Software Development	51	42.5

5. 2. Access to technologies

Figure 1 depicts the level of student access to various technologies outside of campus. Unsurprisingly, all respondents reported that they have access to a cell phone and use one on a daily basis. However, access cannot be mistaken for “ownership” or “exclusive access” - this emerged during the focus groups, where at least two participants claimed that they knew of students (such as siblings or room-mates) who share a cell phone. It is important to recognise that in a developing context, people often share resources and so only have limited access to such resources, which has been corroborated by other studies [12] [4].

As is evident in figure 1, the vast majority of students (n=98, 81.7%) have access to a computer outside of campus. This result must be taken with some caution, as access to a computer is a key requirement for an IT student – not so, for the general student population at the university. However, it is significant that the vast majority of these students (n=82) indicated that they have access to a laptop, while 14 students have access to a desktop and only 2 made use of a netbook computer. Access to mobile computers becomes significant when one considers that campus computer laboratories are currently insufficient (ratio of computers to students in the department is about 1: 7) and over-utilized and that access to such laboratories is often difficult – a typical characteristic of universities in the developing world.

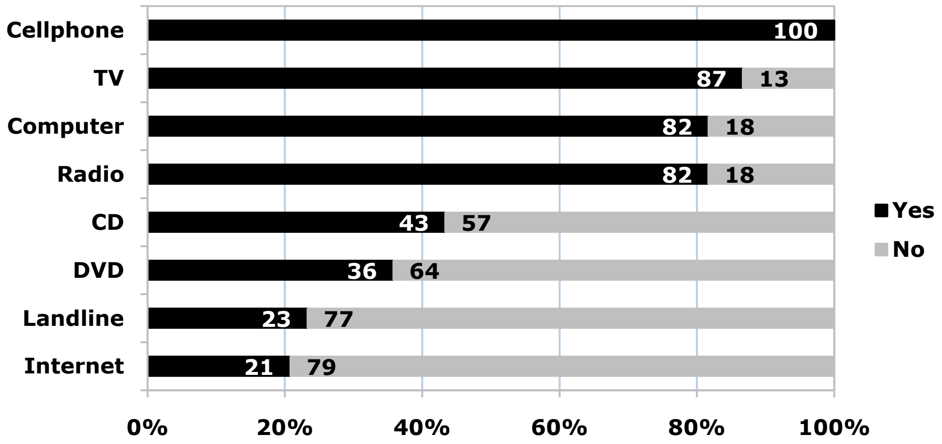

Figure 1. Student access to various technologies

However, it emerged in the focus groups that students who made use of public transport as a means to get to campus were not prepared to carry their laptops to campus for fear of theft. Physical security of mobile equipment becomes an important consideration in a developing context, especially where the public transport system is under-developed and less monitored from a security point of view. Additionally, threats to personal safety while carrying expensive equipment and unaffordable insurance premiums make it almost impossible for students to carry their devices to campus. Some students also reported fear of theft and the potential of misplacing their devices while on campus – the university does not, at present, provide sufficient secure lockers for student use, a weakness it intends to rectify shortly [13].

Access to the Internet (not counting access via smart phones) outside campus is very low – only 21% reported having access from home. Interestingly, 19 respondents indicated that they used 3G while 6 used ADSL/Dial-up connection. Moreover, 88% (n=105) indicated that they accessed the Internet via their cell phones. This is aligned with the general situation in South Africa where a recent study reported that there are about 29 million cell phones in South Africa, compared to a mere 5 million landline phones [19]. The same study reported that 2.8 million South Africans accessed the Internet in 2011 via their cell phones only, while 6.2 million used computers, laptops, and tablets to access the Internet (of which, 90% used their cell phones concurrently) [19]. However, of particular concern to this study is the implication of this result to e-learning. While the university’s Learning Management System (LMS) is accessible from outside campus, it has not, as yet considered the implementation of the mobile version of its LMS. Although a limited number of functions of the LMS may be accessed through a browser on a smart phone, only 21% of the respondents fundamentally have access to the full LMS from outside campus. As is evident from figure 1, a large number of respondents have access to TV (87%) and radio (82%), while a fair number have access to CD players (43%) and DVD players (36%). Delivery of e-learning through these traditional channels become possible in a developing context, but without a key component of the e-learning experience – that of interactive learning. Nonetheless, many successful accounts of using audio and video stored on CD/DVD's have been reported in the early literature on e-learning [5].

In summary, the nature and extent of the access to technologies evident in the foregoing analysis, requires that any implementation of e-learning in a developing context, must give due consideration to using multiple delivery mechanisms on multiple platforms – a requirement that often complicates (and potentially curtails) the adoption of e-learning in developing contexts. Moreover, access to hardware and the Internet is a fundamental requirement and a critical success factor for the implementation of e-learning technologies in a higher education institution in a developing context, where e-learning is seen as a key instrument to improve pass rates in the face of underprepared students, limited onsite computer resources, large class sizes and a diverse student population.

5. 3. Mobile technologies

Respondents were required to report on the make and model of their cell phones, on their service provider, on the type of their cell phone plan, whether they connected to the Campus Wireless Network (CWiN), and other online behaviours. Summary data on 3 of these aspects are provided in table 2.

Table 2: Cell phone characteristics

(a) Cell make	**N**	**%**	**(b) Provider**	**N**	**%**	**(c) Plan Type**	**N**	**%**
Blackberry	54	45.0	Vodacom	53	44.2	Postpaid - Contract	4	3.3
Nokia	51	42.5	MTN	52	43.3	Prepaid - Contract	16	13.3
Samsung	11	9.2	Cell C	13	10.8	Prepaid - Pay as you use	100	83.3
Other	4	3.3	8ta	2	1.6			

Interestingly, BlackBerry and Nokia are the most popular brands among the respondent population. The make and model (not shown in table 2) information provided by the respondents were used to recode a new binary variable (smartphone) in SPSS – the classification was manually verified by the researcher. The overwhelming majority of respondents (n=107, 89%) had access to a smart phone. Consequently, a majority (n=92, 76.7%) of respondents indicated that they accessed the Internet on their cell phones on a daily basis, while 58 (48.7%) stated that they accessed their e-mail accounts on a daily basis. 36 % (n=44) of the respondents indicated that they connected their cell phones to the Campus Wireless Network (CWiN), of which 9 claimed to do so on a daily basis. The main reason students connected their cell phones to the CWiN was to connect to the Internet. However, insufficient bandwidth and other challenges such as firewalls and other security measures make it difficult for students to connect to the CWiN – see [3] for a more detailed analysis. Notwithstanding these challenges, it is important to note that access to the CWiN via smart phone technology means that various servers meant for student access and use from the computer laboratories connected through a campus-wide internal network suddenly become accessible to at least 89% of the student population without access to physical computers. This opens up immense access opportunities to e-learning platforms via the current infrastructure. Moreover, once challenges with respect to connectivity to the CWiN (which the university has committed to address, through its strategic priority 3 on improving teaching and learning infrastructure [14], and through its strategic trust 7 in its 2012-2014 Operation Plan [20]), have been resolved, academic staff will be able to more effectively teach a large class of students while their students view graphics (or slides) on their cell phones and by using voting mechanisms and assessment tools (for example review quizzes) provided by the LMS – this will clearly empower lecturing staff to be more creative in the way they delivered their lectures.

The analysis of the service provider data showed a close alignment to the current market share among 18-24 year olds in South Africa [21]. Unsurprisingly, only 4 students indicated that they had a post-paid contract, while the overwhelming majority used prepaid airtime. The key recommendation arising out of the focus group during discussion of the above was the possibility of the university negotiating reduced rates for data bundles from the service providers. Students were adamant that they will make more use of the lecture materials on their smart phones if they had access to cheaper data bundles – they reported that typically, lecture materials are bulky documents (especially slide presentations and video content) which use up their data bundles at a fast rate.

5. 4. Smart phone use

Respondents were required to indicate which activities they performed regularly on their cell phones. A list of 10 Internet-related activities and a list of 10 common cell phone activities not requiring access to the Internet were provided. The results of the analysis are reflected in table 3 in decreasing order of frequency.

Table 3: Cell phone use

(a) Non-Internet			**(b) Internet-related**		
Activity	**N**	**%**	**Activity (Internet-related)**	**N**	**%**
1. Sending SMS/MMS	113	94.2	1. Instant Messaging/Chat	105	87.5
2. Calculations	105	87.5	2. Academic information search	101	84.2
3. Listening to music	105	87.5	3. Visiting social networking pages	101	84.2
4. Taking photographs	103	85.8	4. Visiting news and sports websites	69	57.5
5. Recording video	86	71.7	5. e-mail	58	48.7
6. Recording audio	77	64.2	6. Downloading lecture materials	53	44.2
7. Listening to the Radio	77	64.2	7. Watching videos	32	26.7
8. Maintaining a diary	68	56.7	8. Reading e-Books / e-Magazines	32	26.7
9. Playing games	58	48.3	9. Reading Blogs	20	16.7
10. Recording lectures	25	20.8	10. Listening to podcasts	12	10

Unsurprisingly, SMS (94.2%) and IM (87.5%) dominate these lists. This can be attributed to the minimal cost of IM and SMS compared to call rates. All focus group participants agreed that they used SMS and IM as a form of communication more than they made phone calls – a common characteristic of the developing world due to the excessively high call cost rates. A consequence of this state of affairs is that students generally find it easier to communicate through SMS and IM compared to face-to-face communication. Students confirmed this during the focus groups and agreed that there existed a potential for the development of poor verbal communication skills as a result. Moreover, as pointed out by [3], students invariably tend to use SMS/IM-language in formal tests and examinations to their detriment. In addition, such practice is curtailing the development of appropriate language skills among the student population – this clearly places an additional burden on academic staff who, for the most part, are grappling with teaching second-language students.

Entertainment and socially-oriented activities (such as using multi-media and listening to music) also feature high on the list of cell phone uses among students. The implication for e-learning here is a positive one – it provides opportunities for developing academic content rich in multimedia for an audience who will most likely enjoy their learning experience because of their familiarity with such technologies.
A very common practice among the student population is to perform even the simplest of calculations on their cell phones – an indication of the poor development of numeracy and mathematics skills at school level. Disappointingly, very few students record their lectures. Focus group participants pointed out that recording video is resource intensive (battery life and memory) and that audio recordings of lectures are meaningless without access to the slides or white board notes. However, they agreed that lecturers recording their lectures and hosting them on the network server will assist them in reviewing the materials when they were preparing for tests.

Encouragingly, students are making use of their cell phones for searching the net for information related to academic functions. Students agreed that the 2 most common Internet searches they performed were for meanings of words (an indication of the difficulty English second-language learners in the developing world experience [3]) and for information that they required to complete assignments. A disappointing observation from table 3 is that most students appear not to be making use of podcasts, e-books and blogs. This could be attributable to the perception that, in general, students do not like to read – an observation that most focus group participants agreed with – albeit reluctantly.

5. 5. Social networking

Respondents were required to indicate which networking sites they used, how often they accessed these sites, and through which devices they accessed their accounts. The overwhelming majority (n=116, 96.7%) indicated that they had a Facebook account and 76 respondents (63.3%) indicated that they accessed their accounts one or more times a day. The popularity of Facebook among South African youth, and indeed throughout the world, is undisputable. Making use of this technology for academic purposes remains a challenge for the academic field. Indeed, students indicated willingness to use such technologies if they could benefit from them.

The second most popular networking site was LinkedIn, with 66.7% (n=80) indicating that they had a LinkedIn account. However, discussion at the focus groups revealed that most respondents have not been using this site for a long period, having only recently set-up their accounts. This was understandable as LinkedIn is a professional networking site and the respondents were final year students hoping to develop their professional networks and looking for potential job opportunities. Only about half of the respondents (n=61) indicated that they used Google+. Focus group participants indicated that most did not really make use of this platform as their friends and relatives were already using Facebook. The micro-blogging site Twitter was the least popular site, with only 53 respondents (44.2%) reporting use of Twitter.

With regard to cell phone access to these sites, only 11 students indicated that they did *not* access their Facebook accounts through their cell phones, while 66 (55%) reported that they did so, on a daily basis. A little less than one-third (n=16) of the respondents who have Twitter accounts indicated that they accessed their accounts on a daily basis on their cell phones. The cell phone use of these technologies were promoted, mainly by the BlackBerry Internet service which allows the applications to remain open and receive push messages on a 24-hour basis without any additional cost. Students also indicated that they made use of RSS which pulled the Facebook and Twitter updates into one page. Immediately, the value of these technologies become apparent, especially in making general and broadcast announcements. Moreover, in a technology-rich learning environment, IM is a useful tool both for discussion and for announcements. Students were required to report on their preferred IM tool. Unsurprisingly, the most popular IM platform among the respondents was WhatsApp (n=98, 81.7%) followed by Mixit (n-68, 56.7%). These tools have been shown to be useful in e-learning contexts, see for example [22] and focus group participants unanimously agreed that the use of such tools both for communication and for academic purposes would be welcomed.

5. 6. Teaching and learning technologies

Respondents were required to indicate how they felt about the usefulness of various Web 2.0 tools in the teaching and learning functions at the university. Six statements phrased in a positive frame were presented and respondents were requested to indicate their degree of agreement on a five-point Likert scale. Descriptive terms were used for the scale points as follows: (5) strongly agree, (4) agree, (3) neutral, (2) disagree, and (1) strongly disagree. The six statements were of the form: “My learning experience will be better if my lecturers used Facebook/twitter [Blogs | Video and Audio | Discussion forum / chat room | Wikis | Podcasts] as a teaching tool.” Figure 2 depicts the results from the analysis of the responses.

Social Networking: While the majority of respondents remained neutral about the usefulness of Facebook and Twitter for academic purposes, more students disagreed with the statement than those who agreed. A potential explanation for the neutrality of the respondents which emerged from the focus groups was that students may not be aware of how these tools could be used for academic purposes. There were suggestions that this could also explain the tendency to disagree with the statement. Students were unanimous, though; that these tools are best suited for general and broadcast announcements.

Blogs: While more students agreed with the statement, the disagreement (25%) could be attributable to a lack of knowledge of how this tool can benefit the learning process. Alternatively, as suggested by the students themselves at the focus groups, this is a clear indication that in general, students don’t like to read and would favour a video blog instead – although they agreed that being forced to write blogs will assist them in sharpening their language and writing skills.

Video/Audio, Discussion Forum/Chat The student responses to the use of these tools to enhance learning is similar with only a small difference in the number who disagreed (Video/audio=9, Discuss/Chat=8). Most students agreed that they could benefit from the rich video content hosted on YouTube and that they were encouraged by some of their lecturers to make use of these, but most generally give up because of the slow Internet connection on campus - a possible explanation for the 9 students' disagreement with the statement. The low bandwidth still continues to hamper progress of ICT adoption for teaching and learning. The majority of students agreed that the use of discussion forums and chat rooms could improve their learning. This is clearly attributed to the fact that most students are comfortable with IM and make extensive use of this technology in their personal lives. Encouragingly, students indicated that they already make effective use of IM for academic activity, especially in work which required brainstorming and collaboration in teams/groups.

Wikis, Podcasts: Interestingly, and seemingly unexpectedly students were evenly split with regards to the usefulness of these tools for academic purposes. According to the focus group, most students were not exposed to using Wikis and were therefore unaware of how it could be used for teaching and learning. On the other hand, students indicated that while they made use of podcasts in their daily lives, they did not believe that the nature of their subjects (mainly practically oriented) were suited to podcasts. This explains why 26 students and 23 students disagreed with the statements concerning Wikis and Podcasts respectively.

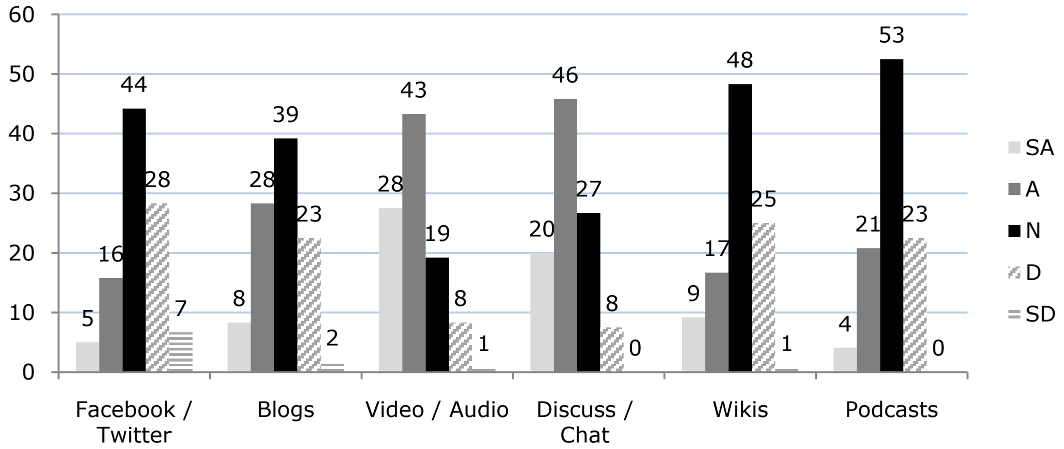

Figure 2. Student perceptions of web 2.0 use in teaching and learning

During the focus group meetings, students indicated that they were excited and impressed with these tools for the most part, but were not sure as to how they could be used for academic purposes. There was strong agreement, however, that students will naturally embrace these tools if they understood how the tools could assist them in the learning process – a clear indication that, in a developing context, awareness, education and advocacy campaigns become key factors in implementing e-learning technologies. This becomes extremely important when one considers that the participants in this study were IT students who are expected to take naturally to these technologies – unlike the rest of the student population.

6. Conclusion

This mixed methods study sought to document how students from a developing university of technology are engaging with ICTs and various Web 2.0 tools both in their personal lives and for academic purposes. An online survey questionnaire was used to collect data from study participants and focus group meetings were used to verify the findings and to gain a deeper understanding of the issues which emerged from the analysis. While the results of the study paint an encouraging picture for the use of e-learning technologies, it must be noted that the target group in this study were IT students. In this regard, further research aimed at the broader student population is suggested and urgently required.

This contribution was intended to provide a deeper understanding of the issues underpinning student access to, use of and perceptions about an array of technology based tools in a developing context. Indeed, in-depth analysis of these issues are required, if we are to take advantage of the potential held by new and emerging technologies, as we move rapidly into the information and knowledge era. Students have indicated a strong willingness to use social networking and other Web 2.0 tools for academic activity – indeed, some are already using these in innovative ways.

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Infopreneurial Behaviour among University Graduates in the Information Science Faculty of a University in Zimbabwe

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Abstract

Infopreneurial behaviour amongst University graduates has the potential to guarantee employment and bridge the gap between job-security and the perceived insecurity of an own information business. At present, the National University of Science and Technology in Zimbabwe offers infopreneurship and entrepreneurship courses to students in the faculty of Communication and Information Science. The course content and presentation are similar in nature as they all relate to the selling, marketing and promotion of information products and services. However distant and limited research has been done to find out the impact of this course in creating an infopreneurial behaviour among graduating students. The researchers conducted a questionnaire-based survey to find out the infopreneurial behaviour among students who graduated from 2008 to 2012 in the faculty. The exploratory investigation reported by this paper brings out the status of these graduates in utilising their acquired knowledge in infopreneurship and entrepreneurship with regards to the selling and marketing of information products and services, especially through small physical or online/internet-based businesses. The major finding of this study was that the later crop of students between 2011 and 2012 have been making initiatives to establish internet-based information businesses but lack further business and technical skills necessary to translate these initiatives into 'real' businesses. These business and technical skills are lacking in the course contents. The researchers conclude by making recommendations on possible adaptations that can be introduced to the courses to improve infopreneurial behaviour among graduating students in information science.

Keywords: *Infopreneurship, Infopreneurial Behaviour, University Graduates, Small Businesses, Job-security*

1. Introduction

Young people's potential to create outstanding information content businesses relies on their education which informs their behaviour as they engage in the information business. University education is a typical knowledge imparting platform from where young people can get infopreneurship education to start viable infopreneurship businesses. This study investigates the infopreneurial behaviour amongst University graduates whose programmes cover courses in infopreneurship at the National University of Science and Technology. These programmes are: Records and Archives Management (RAM), Library and Information Science (LIS), Publishing and Journalism and Media Studies (JMS) students in the Faculty of Communication and Information Science.

1.1. An Infopreneur

An entrepreneur is generally identified as a person who has qualities, attributes and competencies that promote creativity, innovativeness, risk taking, positive thinking; driven by the urge to fully utilise available opportunities and resources to achieve imagined targets that are not normally envisioned by others [1]-[2]. Infopreneurs however, are entrepreneurs who identify opportunities for creating enterprising information-based businesses by identifying knowledge deficiency situations and selling target-based information products and services, mostly through the internet. Infopreneurs are defined as curious, enthusiasts who have the adventurous and driving urge to undertake intelligent searches on wide ranging information (re)sources and to be able to evaluate, repackage and determine the significance, relevance and value of information and information services which they then sell using internet tools to facilitate and enhance their business [3].

Infopreneurs understand and keep abreast of the developments in information and communication technologies, and information business systems in order to identify and access relevant sources of information, knowledge and understanding, target markets, pricing models and relevant customer network trends. Selection, repackaging, sifting, promoting, and distributing knowledge, usually within a niche market is the business of infopreneurs [4]. Infopreneurs are profit oriented enterprising business people running internet based businesses that enable them to sell their expertise to a world-wide audience, by packaging and marketing their knowledge as information based products, online services, and premium consultancy.

2. Review of Scholarship

2.1. The Current "Information Age"

Most scholars [1]-[4] will concur that the current information age characterised by the abundance of information is a typical experience of an information society particularly in countries where increased access to digital applications and instruments are enhanced across society. The information society is characterised by the availability and accessibility of information, bringing about the existence of information entrepreneurship within the society. It also comes with extreme reliance on Information Communication Technologies (ICTs) tools such as computers and their networked environment which facilitates information flow.

2.2. Why Infopreneurs

One scholar [5] posits that "so much information is available that busy people struggle to keep up with the flow." With the advent of the internet, consumers want to access accurate and usable information instantly. Yet most do not have the time, skill and resources to make an accurate search from the myriad of content hosted by websites on the internet. To fill these needs, information entrepreneurs arrange and organise information, making it available in a logical manner. Consumers want to access information that is systematic and in order - the right information at the right time. This opportunity is becoming an even more critical need as new ICTs gadgets for information communication, dissemination and consumption are being produced for business and personal use. As noted by [6], "increasingly, people are demanding tailored packages of information that are relevant to particular requirements issues, or decisions."

The above discussion also points to the rising need of skilful infopreneurs who can be able to mine web content for information required by clients from diverse backgrounds. These skills further relate to the following:

i. Design of websites, analysis of web-content;
ii. Appreciation of web-development software;
iii. Understanding consumer-behaviour;
iv. Business skills acumen/shrewdness;
v. Packaging;
vi. Design of small business proposals, budgets and plans;
vii. Ability of search for small-business funding; and the
viii. Ability to deal with intellectual property issues [7].

Therefore, to meet the informational needs of the consumers, there is a need for infopreneurs whose cognitive and technical skills enable the matching of the needs and the required resources.

Since the information age is characterised by massive amounts of information being available and accessible, while this is an advantage in terms of access to information, it poses a challenge to the users of information. The massive availability of information therefore means that consumers are exposed to all types of information, including information that may not add value to their information needs. It is therefore important to have information entrepreneurs as they filtrate the available information, weeding out what is relevant to consumer needs and screening out information that is not fit for the target markets or for public consumption in general. Information entrepreneurs are important as they have a role to sift, screen, sort and present information in a way that is relevant to different sectors of the economy [8].

2.3. Educating and Training Infopreneurs

Infopreneurs play a crucial role in facilitating the dissemination of information. Information entrepreneurs should be created, developed and supported so as to seize and take advantage of opportunities [9]. The development and support of viable and enterprising information entrepreneurs can be achieved through education and training [9]. Therefore the education of infopreneurs is important in shaping up competitive information business and guaranteeing career occupations for graduates in information science [9]. Education can come in the form of formal schooling in University and College courses offered in Information science programmes. Training is somewhat different from education. It is a unique hands on experience that infopreneurs require in order to fully utilise cognitive or intellectual skills acquired during education sessions. As the characteristics of information products differ from usual goods, there is therefore a need for skills and training which are tailor made for information products [10]. Skills and competencies required to exploit information products are different from the usual goods, [11] therefore different forms of relationships have to be established and sustained.

Therefore academic institutions should consider including in their curriculum, courses that will enable the information entrepreneur to adopt skills that will enable the information entrepreneur to exist in the market and meet the ever rising need for information. One scholar [12] particularly points out that “educators, trainers and developers should establish what needs to be done in terms of course provision, competency assessment and learning support to produce information entrepreneurs”. On that regard, educating information entrepreneurs is key in realising the enormous potential that exists in the information products and services market.

Several studies [8]-[12], indicate that most training and development inputs do not reflect business priorities or result in new strategic capabilities and intellectual capital. There is therefore a need for a shift in the way training institutions reflect at their development inputs as little regard is paid on the business development part. Entrepreneurs exist to provide services and goods to consumers at a profit, thereby creating employment in the process. It is therefore necessary to direct priorities to the profit making aspects of every training programme that is run.

On this regard, the current researchers agree with the notion that there is a need for the creation of information entrepreneurs in this knowledge economy as they facilitate the existing needs of information products. In this current era, consumers need access to their informational needs instantaneously. The development of information entrepreneurs bridges the gap between the consumers and the information. Information entrepreneurs are able to sift and repackage information that is or may be more relevant to consumers, vis-à-vis consumers trying to achieve such on their own [13]-[14]. Market changes are rapid, consumers are unable to cope with the ever changing economy, information availability and accessibility. The existence of information entrepreneurs reduces strain on the consumers while aiding the consumers in achieving and realising their information needs.

However, enterprising infopreneurship requires individual drive and will rather than collective understanding [15]. There is therefore a need for individual dedication on the part of information entrepreneurs on top of the expertise they have in the information management world. The need for information products and services is high, therefore meeting such an increasingly rising need requires dedication at an individual level. Through the above discussed points, the existence of information entrepreneurs is vital in realising the informational needs of consumers.

2.4. Infopreneurship as a Subject

Information, the essential ingredient in today’s knowledge-based economy, is dynamic, expensive, and continually being reconfigured and repackaged [16]. Enterprises are prepared to pay for information that will enable them to increase their profit margins and remain ahead of their competitors. A wide variety of enterprises and individuals have seized the opportunity of turning information provision into a successful commercial venture. Although a few of these ventures have issued from libraries, the majority have originated from the business sector. Many of these businesses provide the same type of information provided by libraries, whereas others provide information which libraries have either ignored in the past, or which they have regarded as being of no real value to anyone. Effectively managing organisational information and knowledge provides information professionals with the key to personal and professional competitive advantage [17].

Today, information specialists are compelled to use new skills and strategies in order to change, survive, and continue to compete in the world of virtual information. Weitzen identified six ways in which infopreneurs generate, organise and disseminate information profitably. These are broadly accepted by different researchers as the way to operate infopreneurship [18]. One researcher [19] identified six ways of profitable infopreneurship which are shown in Table 1 below.

Table 1. Six ways in which infopreneurs generate, organise and disseminate information profitably

Leveraged information: Infopreneurs make use of databases or the internet to obtain general market information and support data for research, as well as for the creation of marketing plans, pricing strategies, distribution channels and advertising programmes.
Customised information: Information that is synthesised and tailored to the user's needs. This included the manipulation of information into a format that is easily understandable (e.g. computer generated graphics).
Facilitating access to information: The information explosion of the last few years increased the need to find the right information in a timely manner. The gap between information produced and information consumed continues to widen, because of the rapid developments taking place today. One solution to this problem is electronic access to information, because this allows infopreneurs to access desired information, select what is valuable and, finally reconstruct and disseminate information selectively to clients.
Speeding up the flow of information: The time-sensitive nature of information requirements ensures a high demand for the speeding up of the flow of information. Today infopreneurs are capable of generating, sending and receiving data virtually instantaneously via the World Wide Web, from and to remote locations thousands of kilometres away.
Repackaging information: The process of repackaging information includes the organising of information into new information products and services. The goal of repackaging information is to locate unrelated and yet possibly relatable information and create new products combining the information.
Around the clock delivery of information: As computers begin to substitute human effort, it becomes possible to deliver information instantly at any time of day or night. This process causes information to take on a value-added quality.

Even though entrepreneurship is wide-spread in the world today, it is still unclear what exactly makes some people good entrepreneurs. However, qualities that are shared by successful entrepreneurs include a need for achievement and acknowledgement, a desire to use their skills to the full, and to be in control of their environment. Above all, entrepreneurs also tend to be those people who are willing to take risks. The past thirty years have seen an enormous increase in the number of universities that started to offer entrepreneurship as a subject [12].

3. Research Strategy

The Faculty of Communication and Information Science at the National University of Science and Technology in Zimbabwe has been offering entrepreneurship and later introduced infopreneurship courses to information science students enrolled for the RAM, LIS, Publishing and JMS programmes. Contributing courses include information economics, web content management and marketing of records and archives products and services. The intention has been to equip undergraduates with the know-how and skills to develop as infopreneurs. The Faculty has a business approach in teaching Information Science with the emphasis on information as a resource. The target market is the end-user, that is, any employee or person who needs information for effective decision-making, especially electronic information available on the internet/World Wide Web. Infopreneurship is a semester course in the fourth and final year of study. Students are taught how to:

i. Be creative yet practical in their search for business ideas;
ii. Research their business idea and ensure that it will be profitable;
iii. Develop information products suitable for the market; and
iv. Plan the way they will be doing business and handle important issues such as financing the start-up and marketing their products or services.

Students who attended the programme between 2008 and 2012 course were asked to complete a questionnaire. The survey was conducted towards the end of the course. As this was only an exploratory study, no claims of generalising the findings to other universities are made. Of a sample of 100 students, 85 students (85%) completed the questionnaires. Their distribution is shown on Table 2 below.

Table 2. Response analysis

Programme	Sample	Number of Respondents	Percentage
RAM	25	23	92
LIS	25	22	88
JMS	25	20	80
Publishing Studies	25	20	80
TOTAL	**100**	**85**	**85**

3.1 An Analysis of the Infopreneurship Course Outline Offered by the University

In this module, students look at the world of the information entrepreneur, a world subject to incredibly rapid changes in information technology – changes which offer numerous possibilities to people with entrepreneurial skills. This course has two major components: the background of the future information entrepreneur and then a more practical part on the origins, development and management of new business. In other words, they explore possibilities available to learned infopreneurs to start their own business. Table 3 below shows course units adapted from The Department of Records and Archives Management, National University of Science and Technology:

Table 3. Infopreneurship course units

Unit 1: The Information World – the World of Information The information era/the information age; The information society; The information professional; The changing world of the information professional; The role of the internet
Unit 2: The Business of Information – New Information Professionals Traditional information work – alternative information work?; Some alternative information professions; New needs, new challenges and opportunities for information professionals
Unit 3: Entrepreneurship and Information Are you an entrepreneur?; Information and entrepreneurship; The information entrepreneur Characteristics of an information entrepreneurship; Opportunities and challenges; Is information entrepreneurship; How do you begin?; Case studies
Unit 4: Starting and Managing a New Business Why and how would I start my business?; Legal requirements; Legal forms a business can take in Zimbabwe; Intellectual property rights; Taxation; Trade licences; Registration with National Social Security Authority (NASSA); Management of new business; Determinants of business survival and growth; Proposal writing
Unit 5: Developing a Business Plan What is a business plan?; Purpose of business plan; To obtain funding; To serve an inside purpose; To be used as a tool for reducing the risk; Who should draw up a plan?; Sections of a business; Problems in developing
Expected Outcomes of the Course After studying this course you should be able to: • Conceptualize the current world in which people working with information as a living function; • Discuss the characteristics of an information society and give your own reasoned view of whether Zimbabwe or part of the country, measures up to these characteristics; • Set up an information business; and • Develop a business plan.

4. Findings

4.1 Infopreneurial activities carried out by graduates

Information gathered from questionnaires regarding the infopreneurship activities carried out by the graduates was collated into categories according to the degree programme and also according to related work activities (Table 4 and Figure 1). Generally, the respondents indicated that they have made efforts at various levels and to various degrees of success in involving themselves or establishing enterprising information businesses in the franchise of the information sector in Zimbabwe.

Table 4. Infopreneurship activities carried out by the graduates categorized according to degree programme.

Degree Programme	Activities	Researchers' Comments
Records and Archives Management	• Data services involving data analysis, database development and support and designing data capturing software • Website design services • Writing and consultancy in records • management research • Records classification and indexing • Registry systems analysis and design • Records surveying • Records appraisal • Automation of records management systems	Whilst most graduates indicate that they are involved in "freelance" infopreneurial activities, they indicate lack of business skills that could enable them to start small information selling/marketing enterprises.

	• Web designing • Research assistantship • Freelance teaching	
Library and Information Science	• Novel, short story, poetry writing • Publishing projects consultancy • Graphic designing services • Knowledge management consultancy • Web/content analyst • Educational publishing • Authorship • Marketing company information products • Book and print media selling & marketing	These graduates have a high understanding of marketing information products. However they indicate that they fall short on bringing their businesses online and lack funding.
Journalism and Media Studies	• Free-lance writing • Paid-Blogging Services • Publishing liaison • Information and documentation officer • Freelance editor • Content cover Designer and Illustrator • Evaluator • Proof reader • Book marketing assistant	These graduates indicate that starting an infopreneurship business is difficult in their discipline as it requires a lot of capital for license, whilst small online publications do not generate workable financial resources. They also indicate a lack of business skills in starting own enterprises.
Publishing Studies	• Services and Products in: Brochures, Fliers, Banners, • Content analysis • Content developer • Freelance writing • Communications design • Print process analyst • Marketing educational materials • Designer • Evaluator • Proof reader • Book marketing assistant	Lack of funding is pointed out as the chief impeding factor in starting infopreneurial businesses. However it is also important to note that the respondents indicate that "it is practically impossible when one has a limited business skill, even though coming from an information background, to start competitive business."

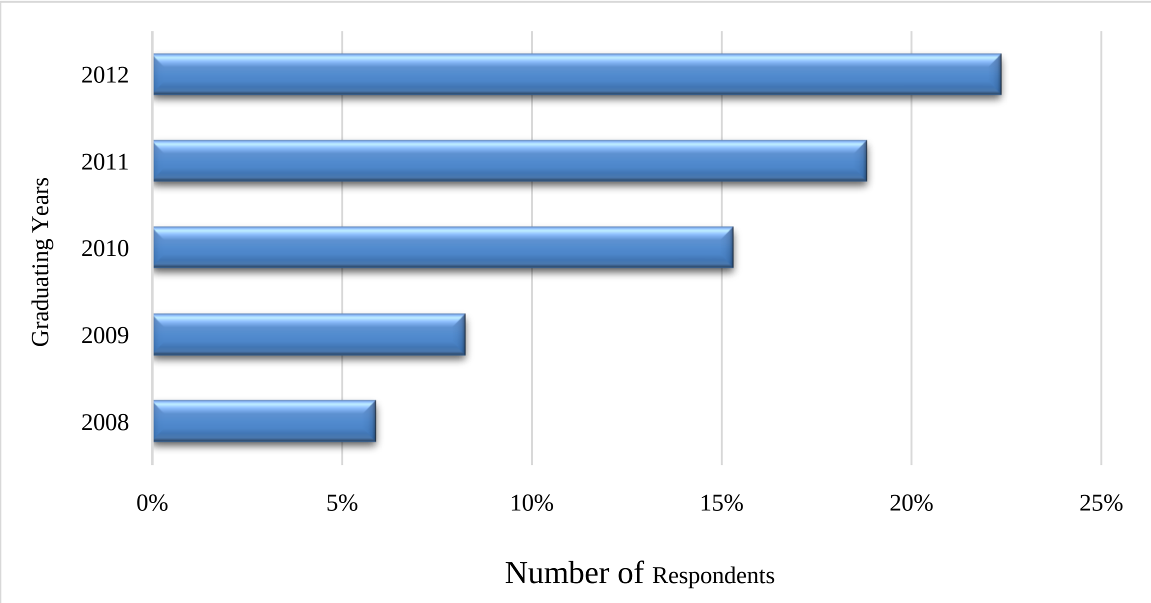

Figure 1. Students Engaged in Infopreneurial Activities

4.2 Challenges faced by graduates in setting up small infopreneurial businesses

Information gathered from questionnaires regarding the infopreneurship activities carried out by the graduates was collated into categories and presented in Table 5 below.

Table 5. Challenges face by graduates in setting up small infopreneurship businesses

Small Business Skills	Respondents' Comments
Proposal Writing	Never had practical sessions at school (To present it quantitatively) Infopreneurship business proposals are different from entrepreneurship business
Budgeting	70% of the respondents indicate that they find budgeting to be problematic
Funding Options	Apart from indicating that they know about several Government funding options, most respondents are unaware of several external funding options
Legal Registration Process	Two respondents gave a detailed explanation of undergoing legal registration process for their small data management consultancy business now currently registered as ARID (Archives, Records, Information and Data) Consultancy Services in accordance with the Companies Act of Zimbabwe. However, generally the other infopreneurs operate 'briefcase' enterprises that are more informal in nature
Planning	All of the respondents indicate that they have clearly written project/business plans which guide their infopreneurial activities.
Intellectual Property Issues	Information product creators are aware of the bearing of intellectual property on their products, especially Publishing and JMS graduates.

4.3 Marketing of Information Products and Services

The respondents were also asked to describe their activities in marketing information products and services. Their descriptions generally indicate that they rely on web-based services to market their products and services which in-turn require ubiquitous internet. This is a problem as most of them indicate that internet connectivity is a problem due to technical, electricity and sometimes lack of financial resources to pay their Internet Service Provider (ISP) in time. One respondent further indicated that some of his customers are not online-based and the digital divide between his online marketing strategy and their absence online has affected his marketing strategy. This basically indicates that whilst online marketing is largely encouraged in the current supposed information society, other physical methods of marketing should not be overlooked. These include newspaper advertisement, Banners, physical market visits etc.

5. Conclusion

The major finding of this study was that the later crop of students between 2011 and 2012 have been making initiatives to establish internet-based information businesses but lack further business and technical skills necessary to translate these initiatives into 'real' businesses. These business and technical skills are lacking in the course contents. The researchers conclude by making recommendations on possible adaptations that can be introduced to the courses to improve infopreneurial behaviour among graduating students in information science.

6. Recommendations

The Faculty of Communication and Information Science in the university under study is strongly recommended to review the infopreneurship course to include content on business skills; business funding opportunities; budgeting; "How to start infopreneurship businesses"; and to blend in other relevant courses to improve the infopreneurial and business acumen of graduating students. These are summarised in Table 6 below.

Table 6. Suggested Recommendations to Information Science Course Curricula

Name of Course	Suggested additions to the current curricula (as of 2013)
Infopreneurship	How to start infopreneurial businesses
Entrepreneurship	We suggest merging this course with the infopreneurship course for information science students to allow focus to be placed much on the information business rather than generic issues to do with other unrelated products.
Marketing of Records and Archives Products and Services	This course should be merged with the Marketing of Library Services Course to a Course: *Marketing of Information Products and Services.* However, possible addition of new information products marketing and management can be done to each course to allow for specificity within each

	discipline i.e. Publishing, LIS, RAM and JMS
Marketing of Library Services	This course should be merged with the Marketing of Records and Archives Products and Services Course to a Course: *Marketing of Information Products and Services.* However, possible addition of new information products marketing and management can be done to each course to allow for specificity within each discipline, i.e. Publishing, LIS, RAM and JMS
Design and Realisation of Internet Tools in Libraries and Archives	This course should be merged with the Web Design and Content Management Course to relate web design to the management of web content, its marketing and how web businesses can be set up using Visa Card accounts
Web Design and Content Management (words in brackets may beaded to the course)	Web-site hosting; Design of Websites using XML and XHML (currently only HTML is taught)
***Start Your Business**	Business planning & proposal writing; budgeting; funding options; legal registration & intellectual property issues
*** This could be added as a new course**	

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Computerized Dynamic Assessment for Improving Problem-solving Skills of Undergraduates

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Abstract

A computer-based dynamic assessment (DA) system developed for use in an undergraduate fluid mechanics course is presented. Data collected before and after implementation of this DA system indicate significant improvement in student performance after implementation. Student performance is quantified by the % of questions correctly answered in the nationally normed Fundamentals of Engineering (FE) Exam relative to the National average. Since implementation of the DA system, this measure for our students has increased from below National level (mean = 0.942; standard deviation (sd) = 0.068) to above National level (mean = 1.068; sd = 0.028). For the same population, performance in fluid mechanics has been higher than that in the other subjects where DA was not used (mean = 1.068; sd = 0.028 vs. mean = 0.854; sd = 0.029). Performance of our students in fluid mechanics has exceeded that of their peers in the top tier programs in the U.S. (mean = 1.068; sd = 0.028 vs. mean = 1.022; sd = 0.020).

Keywords: *Dynamic assessment, Problem-solving, Computerized testing.*

1. Introduction

Dynamic assessment (DA) is a subset of interactive assessment techniques where, the process of learning and knowledge acquisition are tracked so that instruction could be modified to improve student achievement. It involves planned mediation of teaching and the assessment of effects of that teaching on subsequent performance [1]. DA procedures have been shown to yield different types of information including: more valid measures of student abilities than through static tests; measures of learning ability or “modifiability”; insights into the cognitive processes that students use or fail to use; and clues about instructional methods [2], [3]. Almost all researchers working on DA have found that test performance improves after mediation through DA [1] – [5]. It is in contrast to traditional static tests that test acquired knowledge, without any attempt to intervene in order to change, guide, or improve the students’ ability to learn and potential for achievement [2], [5], [6].

Several other benefits of dynamic assessment have been recognized in the cognitive research literature. DA with diagnostic monitoring and context-sensitive prompting and feedback has been found to be an effective approach to improve student achievement [1]. DA facilitates near and far transfer of mediated strategies to the solving of new problems [1], [3], [7]. Extent of gain in DA tasks has been shown to be a good predictor of later academic accomplishments [1].

However, a negative aspect of DA is that classroom implementation of DA demands considerable effort and time on the part of the instructor. As such, we have developed a prototype version of a computer-based DA system for use in an undergraduate fluid mechanics course (CE 331) at New Mexico State University (NMSU). The first version of the computerized assessment system initiated in 2000 did not incorporate dynamic assessment. Since its implementation, it has been formatively refined over several semesters incorporating student feedback on its usability and clarity as well as research reports on dynamic assessment. The current version of the DA system has been in use since 2004. Details of this system, its development and refinement, and its validity have been presented elsewhere [8] – [11]. An overview of the DA system is presented in the next section. The goal of this paper is to present multiple measures collected over several semesters to demonstrate the effectiveness of the computerized DA system in improving student performance.

1.1 Overview of DA system

The DA system consisted of 5 Assignments. Each Assignment included a review of 4 new concepts (C1 to C4) followed by a Concept Quiz followed by 5 Problems (P1 to P5). Each of the 5 problems has five “surface variations” (V1 to V5) where the problem statement, the numerical data, the required result, and the correct response choice are changed dynamically at run time, for each session. The first problem (P1) requires application of two of the four concepts (C1 and C2) and the second problem (P2) requires application of the other two concepts (C3 and C4). The third problem (P3) requires application of all the four concepts (C1 to C4) and the fourth (P4) and fifth (P5) problems require application of all four concepts covered in this assignment as well as concepts learned previously in this course, the first course, as well as other prerequisite courses (e.g. statics). All the problems are multiple-choice type with four choices (A, B, C, and D) each. Students have the option of asking for "Hints" before making a selection, but would lose 20% of the points for that problem for doing so. Once a selection is made, immediate response is provided, and if necessary, students can view the complete solution.

In any assignment, all the students are first offered Problem P3. Depending on their performance in this problem they will be directed to either Problem P1 or P4. If they solve Problem P3 correctly without requesting Hints, they get 100 points for it and are offered Problem P4. If they solved Problem P4 also correctly without requesting Hints, they would get 100 points and continue with problem P5. On successful completion of problem P5 without the use of Hints, they receive an average score of 100 for that Assignment. If they solved P3 incorrectly without requesting Hints, the solution is presented, and they are allowed to try another version of P3 again after reviewing the on-line notes. Alternatively, if they requested Hints for Problem P3 and solved it correctly, they get 80 points for Problem P3 and are then offered Problem P4. If students failed to solve Problem P3 correctly after reviewing the Hints, they can review the solution and will be directed to the appropriate section in the on-line review notes. From there, they are directed to Problem P1 and sequentially to the next four Problems. On completion of an assignment, if the student is not satisfied with the average for that Assignment, the student can redo that Assignment following the above cycle until the student is satisfied with the score.

Students are now allowed unlimited number of attempts for each assignment within a week, but each assignment had to be attempted at least twice, even if a perfect score of 100 points is received at the first attempt. The average score of the top two attempts is taken as the score for that assignment. This motivated the students to return to the DA system as often as they wished, so that they could achieve the highest scores that they were satisfied with. Because of the dynamic variation of the problems, and the randomly picked versions (V1 to V5) of each problem (P1 to P5), all the students had repetitive opportunities to try "different" problems each time they attempted an assignment.

2. The study

Recognizing that it is not possible to make direct assessment of student learning and achievement and relate that to specific interventions and remedial actions, we propose the use of the results of the Fundamentals of Engineering (FE) examination as an indirect, external measure. The FE Exam, administered biannually by the National Council of Examiners for Engineering and Surveying (NCEES), is a nationally normed exam that over 6,000 civil engineering graduates take every year during their senior year in college. This exam has two 4-hr sessions, one in the morning and one in the afternoon. The morning session of this test covers 12 subject areas common to all fields of engineering, including fluid mechanics. A summary report of the results of the FE exam showing the % of questions answered correctly in each subject area by the program students as a group is provided by NCEES to the students' departments. This report also includes corresponding percentages for candidates from three comparator groups- candidates from the Carnegie 1 (Very High Research), Carnegie 2 (High Research), and Carnegie 3 (Masters) institutions, as well as the overall National average.

We have used a performance index, PI, defined as follows to assess the improvement of our students:

$$PI_{j,k} = \frac{\%\ of\ questions\ correctly\ answered\ by\ group\ j}{National\ ave.\ of\ \%\ of\ questions\ correctly\ answered\ in\ subject\ k}$$

In this paper, the PI is used in the following three ways:

1. Comparison of PI of our students in fluid mechanics before and after implementation of the DA system (j = NMSU; k = fluid mechanics)
2. Comparison of PI of our students in fluid mechanics against their PI in other subjects (j = NMSU, k = fluid mechanics vs. other subjects)
3. Comparison of PI of our students in fluid mechanics against PI of peers in Carnegie institutions (j = NMSU vs. Carnegie Institutions; k = fluid mechanics)

3. Findings

3.1 Comparison of performance index: before and after implementation of DA

Prior to initiation of the computerized system in 2000, the performance of our students in the FE exam was significantly below the National level, with average PI of 0.872 (sd = 0.148). During the initial stages of the implementation of the system (2000 to 2003), PI increased to 0.964 (sd = 0.081). Since implementing DA in Spring 2004, PI has increased further to 1.068 (sd = 0.028), exceeding the National performance [9]. Since the instructor and the teaching methods have remained almost the same since 2000, the gradual increase in the performance in the FE Exam is attributed primarily to the computerized DA system. This claim is corroborated further by additional analysis of the FE Exam results as discussed next.

3.2 Comparison of performance index: fluid mechanics versus other subjects

Figure 1 compares the performance of our students in fluid mechanics against the average of their performance in the other 11 subjects covered in the morning session of the FE exam. The following two observations can be noted from this figure. First, there is a step increase in the performance in fluid mechanics, coinciding with the implementation of the DA system: the performance (as quantified by mean PI) increased from below National level of 0.942 (sd = 0.068) pre-DA to above National level of 1.068 (sd = 0.028) post-DA. It has to be noted that the students take the FE exam 3 semesters after they take this course and the instructor had remained the same over pre-DA and post-DA periods.

Second, the performance in fluid mechanics post-DA has been significantly higher than that in the other subject areas, which has remained consistently below National level from 2000, at a mean PI of 0.841 (sd = 0.029). In fact, there is no significant change between the mean PI for the other subjects, pre-DA (mean PI = 0.834; and sd = 0.028) versus post-DA (mean PI = 0.844; and sd = 0.029). This comparison for the same population of students supports the claim that their higher performance in fluid mechanics is probably due to the DA system that was used only in the fluids mechanics course.

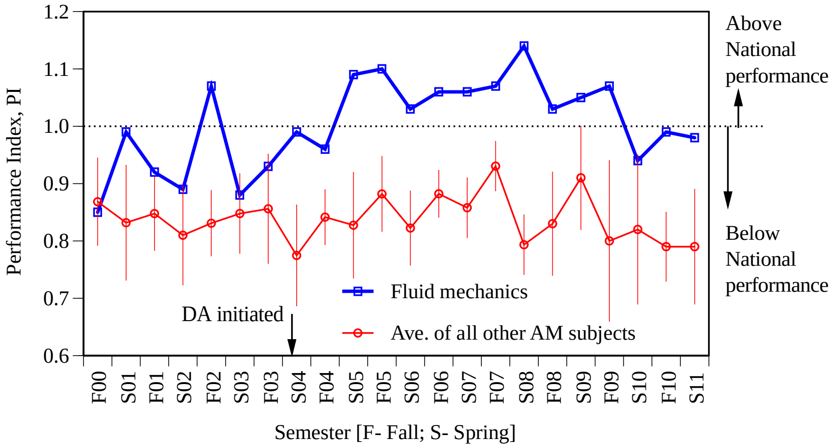

Figure 1. Percentage of questions correctly answered by NMSU students relative to National peers in the AM section of the FE Exam, from Fall 2000 to Spring 2011

3.3 Comparison of performance index: our students versus Carnegie peers

A comparison of the PI of our students in fluid mechanics against that of the 3 comparator groups over the past seven administrations of the FE Exam is shown in Figure 2. As can be seen from this figure, pre-DA performance of our students had been below the performance of Carnegie 1 and Carnegie 2 peers. However, post-DA performance has been consistently and significantly above that of Carnegie 1 peers: mean PI = 1.068 (sd = 0.028) versus mean PI = 1.022 (sd = 0.020). This comparison affirms that the step improvement in performance of our students in Spring 2004 is not due to any fluctuations in the standard of the fluid mechanics section of the FE exam, but due to the DA system used at NMS4 that helped improve their achievement.

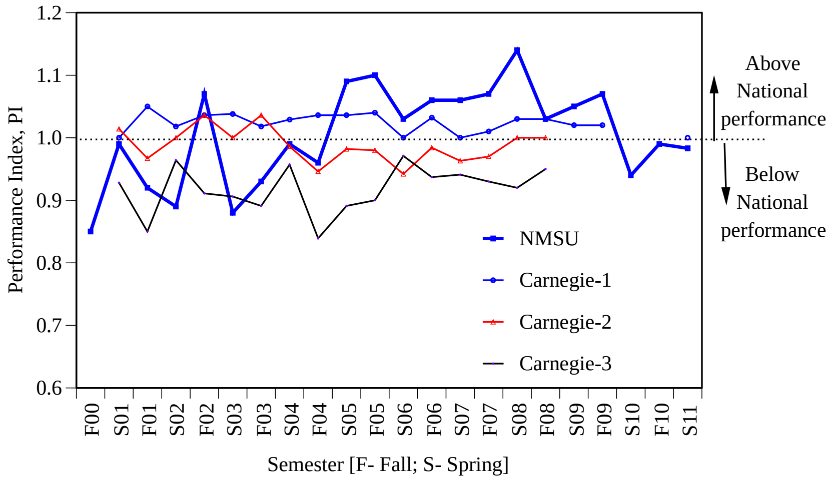

Figure 2. Percentage of questions correctly answered by NMSU students relative to National peers in the AM section of the FE Exam from Fall 2000 to Spring 2011

The box-and-whisker plot in Figure 3 summarizes the above comparisons in terms of 10th percentile, 25th percentile, mean (o), median, 75th percentile, and 90th percentile of the PI values for the different groups. These comparisons validate the notion that the computerized DA system presented in this paper is beneficial to the students in improving their problem-solving skills and achievement in the FE exam.

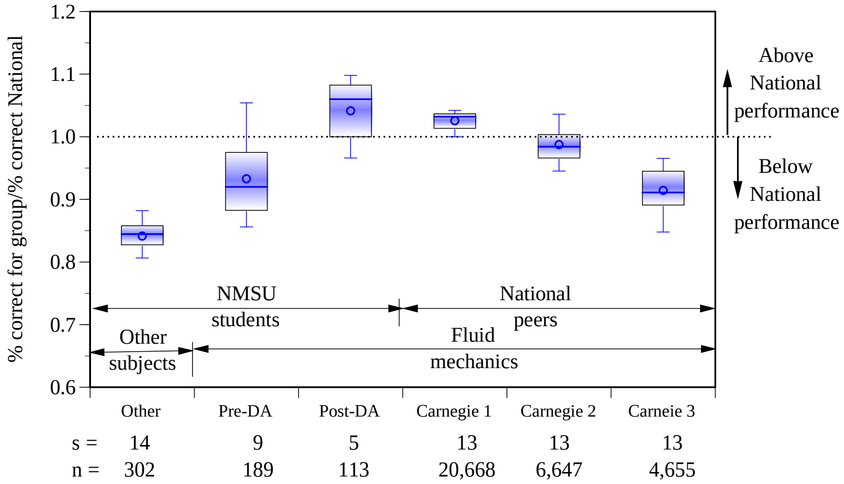

Figure 3. Percentage of questions correctly answered in the morning section of the FE Exam: NMSU students relative to National peers: s- number of semesters; n- number of students taking the FE test

4. Conclusions

It is worth nothing that our students take the fluid mechanics course (CE 331) during the junior year and take FE exam about 3 semesters later in their senior year. They do not take any further courses in this area beyond CE 331. Yet, the FE exam results indicate that the skills developed and the knowledge gained using the computerized DA system were long lasting for successful far transfer. This benefit of the DA approach is also in agreement with similar findings reported in the literature [1], [3], [7]. The system enables students to learn the material by working problems individually, with help provided by the DA system. In contrast to traditional homework assignments where students tend to work on the problems in groups, this system helps students to solve problems individually and learn from their errors by themselves, with immediate feedback and prompting. This feature of the system that cultivates individual competence could be a reason for the increased performance of the students in the FE exam, which is designed to measure individual competency rather than group effort.

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Presenter: This paper is presented by Nirmal Khandan

Adjustable Simulation-based Virtual Laboratories for Learning Telecommunication, Alternative Energy, and Energy Conservation

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Abstract

The paper presents multilayered highly interactive simulation-based integrated and adjustable virtual laboratories for engineering and technology education focusing on alternative energy and energy conservation courses. These labs are designed to enhance the understanding of technical concepts and underlying fundamental principles, as well as to help students master certain performance based skills in an online environment. Realistic simulations visualize processes occurring in the devices and enable students to observe the physical processes at different levels, analyze constraints between physical parameters, compare actual and virtual data, and much more. The simulations and labs also help students explore the economic aspects of using alternative energy devices. The virtual labs can be used in conjunction with the related hands-on labs to form the hybrid laboratories to be delivered via either online or on-site teaching methodologies. An easy-to-use tool that enables instructors with no-programming experience to produce appealing and pedagogically sound interactive virtual activities is available as well.

Keywords: *e-Learning, Virtual laboratories, Simulations, Telecommunications, Alternative energy, Energy conservation*.

1. Introduction

Computer simulation plays an important role in engineering programs by providing a learning platform that facilitates an efficient and effective way of teaching complex and dynamic engineering systems. Today, with many colleges offering distance education programs in engineering and technology, the demand for truly interactive simulation-based online labs is on the rise. Interactive virtual laboratories (vLab) are capable of partially substituting or extending conventional hands-on laboratories. vLabs have great potential for facilitating the active learning mode and transforming “e-learning by reading and watching” into a more efficient “learning by doing”. They also provide an efficient and effective way of teaching complex and dynamic engineering systems. A simulation-based teaching environment enables students to acquire experience and evaluate their previous results [1].

An onslaught of networks and services demand driven by the explosive use of mobile devices and phenomenal interest in renewable energy and energy conservation technologies has led to an increased demand for engineering and engineering technology graduates who are not only skilled in installation, maintenance of equipment used in telecommunications and the intelligent infrastructure systems required to generate and supply electricity in commercial and residential applications, but who also understand the fundamental principles underlying the design and operation of relevant systems and devices. However, incorporation of such learning processes and the state-of-the-art technological tools and equipment requires considerable time and financial resources. Keeping curricula and labs current with the rapid change of technology poses another challenge for faculty. Engineering and engineering technology professors can address some of these challenges by using simulation and virtual experiments [2]. In addition to cost savings, simulation offers a number of other advantages:

- Allowing the user to modify system parameters and observe the outcomes without any harmful side effects.
- Eliminating component or equipment faults that affect outcomes.
- Supporting users progress at their own pace in discovery and understanding of concepts and issues.
- Enhancing the presentation of “dry” concepts by integrating theory and practice.

However, simulation is not a panacea for the problems of keeping curricula current, as it has some limitations too; for example, the use of software simulations of physical entities, such as electronic circuits, denies the user a chance to physically handle the circuit components or construct the circuit [3]. In the areas of electrical and electronics engineering and technology, there are numerous uses for simulation, starting from simulation of electric circuits to complex tasks such as electromagnetic fields, networking, computer circuits, game programming, electron flow in semiconductors, and manufacturing process control and monitoring.

2. Virtual laboratories

The core components of educational tools discussed in this paper are highly interactive and complex Java and Adobe Flash simulations, with associated HTML/XML parts and scripts. State-of-the-art graphical interfaces and realistic models of the simulations provide an "insight" view of the processes and help users become familiar with the internal structure and operation of complex engineering systems and devices. A simulation is task- and learner-neutral; it models an object/system construction and operation or learning situation. Within simulation functionality, there are no restrictions on the student’s actions.

The simulations presented in Figure 1 are parts of the module “Wireless Fundamentals” that help students conceptualize the physical principles underlying the operation of various mobile devices.

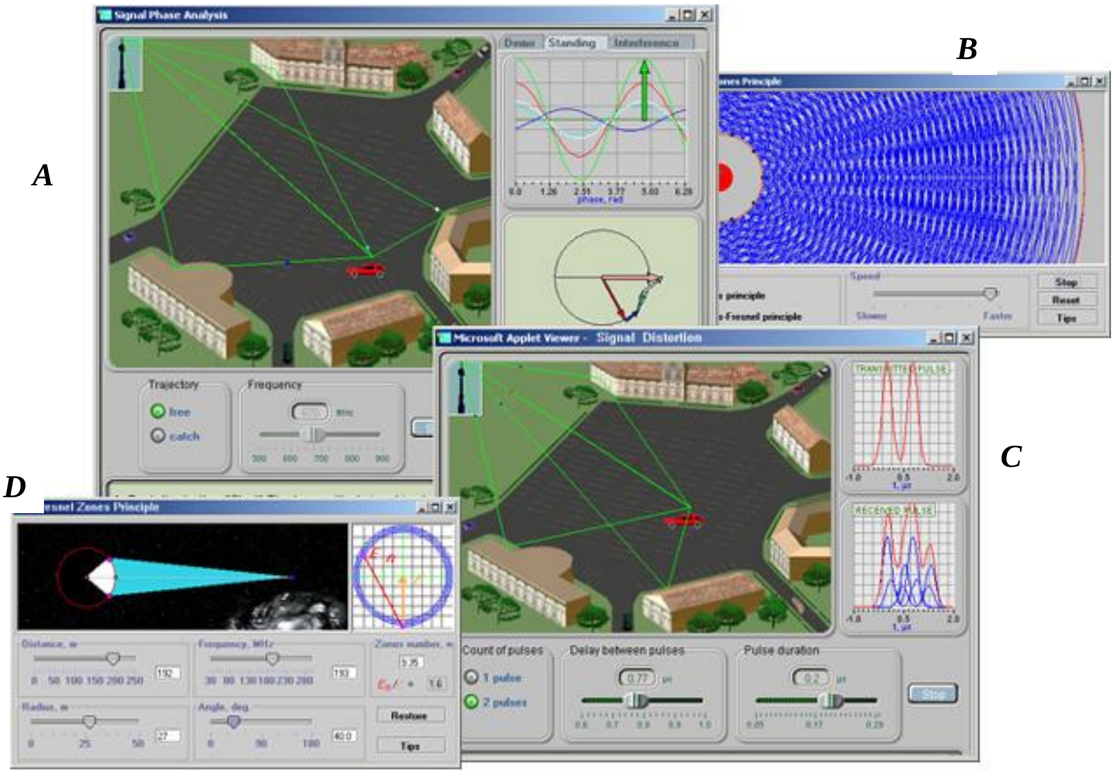

Figure 1. Simulations shown above are designed for virtual exploration of signal reflection and distortion effects. Using the drag and drop option (on the simulations ***A*** and ***C***), a student can move the car around a parking lot and to see the effect of different reflections from surrounding buildings on the signal shape, phases, and amplitudes. Student can choose between one or two pulse signals, vary signal

frequency, pulse duration and delay between pulses. Simulations ***B*** and ***D*** help the student understand the Huggens-Fresnel principle, and the impact of various parameters on the structure of Fresnel's zones, as well as what sources of secondary waves should be taken into account during the calculations.
Realistic simulations enable learners to:

- Observe the physical processes insightfully at different levels of detail (micro and macro)
- Analyze the constraints between relevant parameters (relationships)
- Push these parameters beyond normally allowed values to simulate infrequent operating conditions or casualty situations (cause and effect)
- Run "what IF" scenarios (minimizing risk)
- Acquire data from virtual experiments for detailed analysis and comparison to actual operating conditions in a theory-to-practice approach. (This narrows the understanding gap between theory and practice.)

Virtual labs contain expandable sets of online experiments, as well as relevant learning resources and assessment activities. In contrast with a simulation, an online experiment is a guided activity which focuses on a particular educational task. It includes specific learning objectives, scenario/assignment, worksheets, embedded assessment, and, most importantly, step-by-step instructions for students. Virtual experiments may also include optional auxiliary simulations, prerequisites, excerpts from interactive lessons and technical manuals to facilitate "just-in-time" learning, quizzes, and online reference resources. The student is expected to follow a thorough a set of step-by-step instructions to accomplish a particular educational assignment. Each online experiment is a distributed object that shares simulations and supplementary e-learning resources available within or outside its vLab.

The virtual laboratories implement technologies that can provide instructional opportunities in many modes, whether at campus or school (traditional teaching), at home (warm-ups, post-class tasks, or self-learning), or through distance learning.

Some virtual laboratories facilitate a multilayered approach to studying system design and operation. Relevant virtual experiments are typically comprised of several interacting simulations. The main purpose of such an experiment is to bridge the gap between technical skills and the scientific knowledge. The screenshots of simulations that form one of our multilayered telecommunications labs are presented in Figure 2.

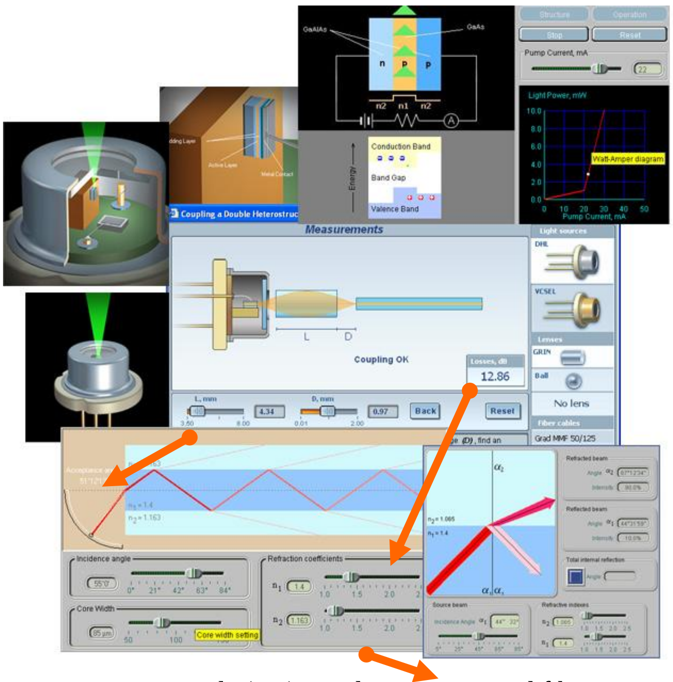

Figure 2: Laser Diode (LD) coupling to an optical fiber system.

The lab enables students to perform following tasks:

- Assemble a Laser Diode to Fiber Coupling using different types of light sources, lenses, and fibers,;
- Explore the design and operation of the system components;
- Learn underlying fundamental principles.
- Study the impact of various design and operating parameters on the coupling losses;
- Collect and handle data generated by mathematical models that describe the relevant physical processes;

Figure 3 presents simulations related to the module “Alternative Energy and Energy Efficiency” that includes interactive web-based e-learning resources that model and describe the systems and appliances of a solar powered house.

Figure 3. A collage of screenshots of a solar powered house simulations.

The simulations, shown in Figure 3, enable students to explore how efficiency of the solar photovoltaic (PV) and roof heating systems depends on geographical location, orientation, seasons, weather conditions and some other factors.

Users are able to choose from a list of geographical locations of major American and foreign cities or enter a latitude of a particular place, rotate the house, vary the angle of the solar panels, switch between fixed and sun tracking PV systems, change date, time and weather conditions, alter electrical load and immediately see how these changes influence energy production and consumption.

The controls and meters (bottom right) allow user to monitor, collect and analyze data, as well as to estimate energy (and money) savings due to the solar power system and energy efficient appliances. Virtual experimentation helps students develop their understanding of all the pros and cons of a solar thermal and photovoltaic systems and assess the net effectiveness of home appliances.

Students can also use the set of simulations (Figure 4) that model and visualize the basic processes occurring in semiconductors.

Figure 5 shows the virtual experiment designed to study heat transfer and thermal conductivity of building materials. In this particular experiment students should determine the impact of wall insulation materials on the cost of maintaining comfortable temperature in a house. First, students are presented with the specific learning objectives and experiment description. Then a simulation is launched.

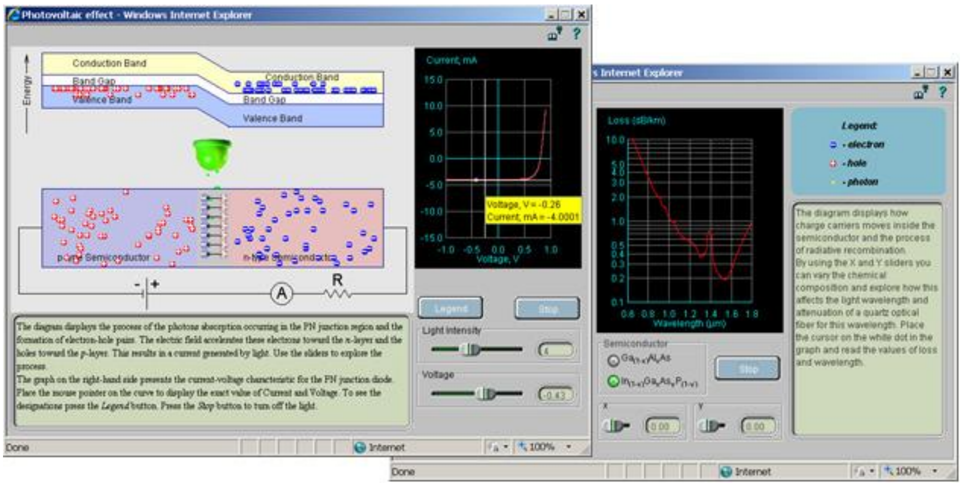

Figure 4. These simulations enable students to study photovoltaic effect in semiconductors and explore how various radiative loss mechanisms in a semiconductor depend on the composition of the material. Students are able to vary light intensity and applied voltage (left screenshot) and to study how these parameters affect the current-voltage characteristic of a photovoltaic device. This helps students better understand fundamental laws underlying the operation of photovoltaic panels.

Figure 5. An example of a virtual experiment "*Influence of Thermal Wall Insulation on Energy Expenses*".

The simulation, which is the foundation of the virtual experiment (Figure 5), enables students to vary the thickness and type of materials used for the wall and insulation, inside and outside temperatures. By selecting different materials the students can instantly see how these changes impact energy consumption and the monthly utility bill. An instructional panel beneath the simulation displays step-by-step instructions for the student. An Excel spreadsheet (or simple worksheet) can be opened within the experiment. It can also be printed out for a traditional "paper and pencil" mode. The spreadsheet helps students to conduct the experiment and to collect and analyze the data. From within the main simulation an auxiliary simulation (shown in the middle left) can be called up for additional exploration.

Each online experiment includes an associated control quizzes (shown in the top right) that can be answered either online or in a "pen and paper" mode. An embedded lesson (in the middle) provides "just-in-time" learning opportunity.

The described vLabs can be easily customized even by instructors with no programming or scripting experience using the available authoring toolkit and templates. The instructors are also able to produce new appealing and pedagogically sound online experiments and performance-based assessment assignments that can be integrated with online or blended courses.

3. Conclusion

A number of simulations and virtual experiments based on the described software have been incorporated into engineering courses at the Ghana Telecom University College. The student surveys included questions designed to assess student engagement with online experimentation, their satisfaction with the virtual vs. traditional labs, impact of visualization and interactive simulations on students' understanding, and overall learning experience. The students' responses revealed that online experimentation provides a systems overview, and helps students develop a good conceptual base.

Students also believe that vLabs are easy to use and their effectiveness is enhanced by interfacing them with external systems in order to provide a hand-on experience for users. Every four out of five students strongly recommended to include similar virtual activities in other online and blended courses.

Responses of GTUC students were very similar to the feedback and assessment results of American undergraduates [4]. The software was more effective in promoting student learning when it was used in a hybrid (hands-on and simulation) mode. This fact is also supported by the findings of a recent research study conducted at DeVry University [5] which shows that online and blended experimentation reduces the gap between theoretical knowledge and practical experience. It is preferable that students are first exposed to theoretical concepts in the simulation environment, and then required to perform a hands-on activity.

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Distance Learning With Social Media

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Abstract

The concept of Distance Learning has been around for quite some time for people seeking Non-Traditional paths, but in the past decade it has gained widespread popularity. One reason for the increased popularity of Distance Learning is a high degree of flexibility. The structure of Distance Learning gives students the greatest possible control over the time, place and pace of education. At the same time, Social Media have gained wide societal interest. In this paper we will explores the potential of Social Media for increasing student engagement for Distance Learning. Loss of student motivation due to the lack of face-to-face contact with teachers and peers, potentially prohibitive start-up costs, and lack of faculty support are all barriers to successful Distance Learning. Because these students are often not on campus, they do not fall under the traditional paradigm of engagement that includes faculty-student interaction and active and collaborative learning in a face-to-face classroom.

Keywords: *Social Media, Distance Learning, Online Education.*

1. Introduction

Distance Learning is a formalized teaching and learning system specifically designed to be carried out remotely. It is a reliable alternative to face-to-face education. It is less expensive to support and is not constrained by geographic considerations, it offers opportunities in situations where traditional education has difficulty operating. People with scheduling or distance problems can benefit, because it can be more flexible in terms of time and can be delivered virtually anywhere. After discovering the benefits of Distance Learning, many people are choosing Distance Learning programs [1]. One in four higher education students in the United States now take at least one online course during their undergraduate career. Evidence of the growth of Distance Education can be seen in the results of a survey conducted by National Centre for Education Statistics America in 2011 there were about 4.3 million undergraduate students that took at least one Distance Learning course or Online course (Figure 1). This amounts to 20 percent of all undergraduates enrolled in the 2007-2008 year. There were about 0.8 million or 4 percent of all undergraduates that completed their entire undergraduate degree online during the same period.

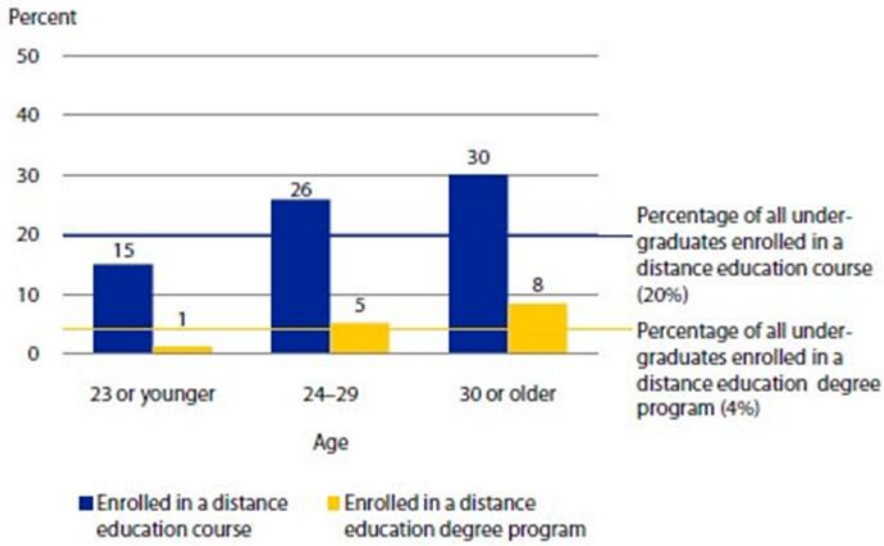

Figure 1. Distance learning course or online course
according to the data of National Centre for Education Statistics America in 2011

The most striking difference between the Traditional and Distance Learning classrooms are in the area of communication and interaction. Faculty members in the Distance Learning environment do not have the benefit of seeing student's nonverbal cues to gauge how well they are teaching [2]. So Distance Learning requires different communication methods than those needed in traditional classrooms. Popular present day methods include:

a) Voice-centered technology, such as CD or MP3 recordings or Webcasts
b) Video technology, such as instructional videos, DVDs, and interactive videoconferencing
c) Computer-centered technology delivered over the Internet or corporate intranet

These platforms have generally been used as static repositories of content, failing to provide the robust social experience found on platforms that have garnered societal interest and appeal, such as Social Media Sites.
Furthermore, these platforms have been criticized for suppressing motivation and enthusiasm and failing to support personalization. As a result, educators have begun exploring alternative platforms to provide learners with the social communication tools that allow for ease of use, pedagogical freedom, fluid online discussions, and identity management. Social Media has been viewed as a tool that enables the use of participatory pedagogies able to address the problems that have traditionally plagued Distance Learning: creating a sense of presence, community-building, and learner participation in interactive discussions [3]. In this paper we find that using online Social Media as educational platforms may support learners in forming social connections with others while they collaborate to share ideas, create products, construct identities, and receive timely feedback.

1.1. Social Networking Sites

Social Networking Sites have become significant part of our modern life and have created a whole new world where we are free to express our opinion and share it with our friends and peers. This world of Social Networking gives scope to everyone to express and share ideas, thoughts and feelings, who want to be the part of it. It is a defining trait of how integrated our social interactions have become. These Sites are virtual spaces that build virtual communities through sharing experiences, communicating personal information, and connecting to friends. These are a primary means of communication and have moved private lives into a public forum [4]. According to a study conducted by Pew Research Center America December 2012, 67% of online adults use Social Networking Sites (Figure 2). Women have been significantly more likely to use Social Networking Sites than men since 2009. In December 2012, 71% of women were users of Social Networking Sites, compared with 62% of men. The use of Social

Networking Sites among young adult internet users ages 18-29 jumped from 9% to 49%. Social Networking Site use by age group, over time:

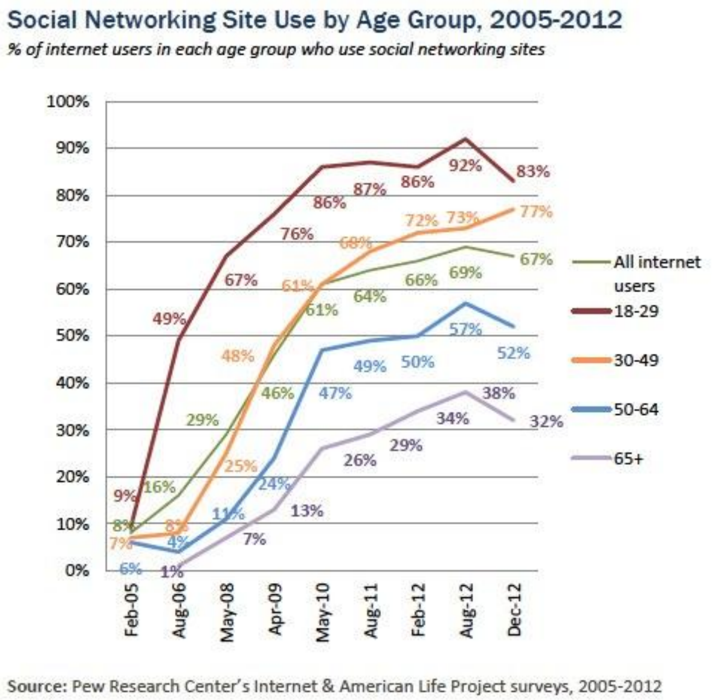

Figure 2. Social networking site use according to a study conducted by Pew Research Center America

The extensive use of Social Networking Sites and their reliance on society make them essential to consider as ways to promote student engagement. Moreover, these sites provide a social outlet for students despite the barriers of distance, and it has been shown that interaction with friends at school is significantly higher for students who spend more time on these sites [5]. Social networking sites are an

"easier way to connect in a disconnected world".

Social Networking Sites encourage user contributions and participation, and the services are more users oriented instead of content oriented. The services allow users to participate in online activities in a proactive way. With Social Networking Sites, users easily share information, comment, and even modify other user-created content. The open atmosphere greatly encourages content sharing and allows users to get feedback on content they have created. Compared to traditional media, Social Media promotes two-way communication among users [6].

Also facilitates community building for users of similar interests. In a user group community, users can stay focused on relevant content and topics that everyone is interested in, and with the connections to other users, they can easily keep up on what is happening in a particular field. All of these features not only benefit professionals and computer geeks, but they are also same valuable to Distance Educators and Learners.

1.2. Social Networking Sites as Educational Tool

When appropriately integrated into the online classroom, Social Networking Sites can offer innovative learning experiences and enhanced learner engagement. Distance Learning in past has been plagued by feelings of learner isolation and alienation, lack of participant interaction (both student-student and student-instructor), and high dropout rates. Social Networking Sites have the potential to facilitate interaction, communication, and collaboration [7]. Social Networks enable learners and instructors to present themselves socially in an online environment and connect with one another while enabling individuals to engage in recurring meaningful experiences with others. With the prevalence of various tools, faculty can design creative online learning activities by asking students to use one or more tools to work on their learning tasks and achieve their learning objectives.

Online collaboration becomes much easier when it is facilitated by Social Media technologies. For instance, students can collaborate on team project documents. Students in the same study group can co-draft documents, spread sheets, presentation slides. Each study group can also create a presentation through a Web conferencing tool. With the popularity of blogging and micro-blogging, it is not uncommon for faculty to use blogs as additional teaching/learning resources. Faculty may publish academic journals or articles on his/her own blog and students may post discussion comments on them in the threaded comments area [8]. Discussions can become an extension of learning in the online classroom, and they can help students keep up with what is happening in the real world. Some faculty has even used online accounts to remind students of homework, upcoming events, and other important items. Students can immediately receive these reminders through their mobile phones if they have the correct setup in their online accounts. Academic research can also benefit from using Social Media tools. In particular, social bookmarking is extremely useful for literature reviews and collaborative research. Many professors teaching graduate-level classes found that Social Media is an attractive tool to assist students with their own research projects. By using the highlighting and sticky notes, online reading becomes much easier. Students can review and respond to the reading notes from their classmates and the instructor. As a result, reflective thinking and collaborative learning are highly encouraged with this tool [9]. Social Media also allows students to build or join communities to connect with people who share the same academic interests, leading them to easily share and locate more resources that are relevant to their research topics [10].

1.3. Social Media in Career

Social Media has created a new breed of marketing, which has required professionals to build and further the field. As Social Media users join the workforce, they bring their skills to their careers. Social Media prepares young workers to become great marketers. It has become essential for major businesses to include a Social Media marketing strategy and students today are the people filling these positions.

Social media sites help employers find employees and job-seekers find work. 64% of companies are on two or more social networks for recruiting because of the wider pool of applicants and more efficient searching capabilities. 89% of job recruiters have hired employees through LinkedIn, 26% through Facebook, and 15% through Twitter. One in six job-seekers credit social media for helping find their current job. 52% of job-seekers use Facebook for the job search, 38% use LinkedIn, and 34% use Twitter. While older generations might not completely understand or agree with the amount of social media activity by today’s student population, they will quickly benefit from it. As technology advances, so does the way the world works with it. Members of the young workforce are keeping up to speed with many forms of Social Media. Once you get a proper Social Media marketing strategy locked in, you’ll be grateful for the recent graduate you’ve hired to carry out the details.

2. Pro and Cons

Researchers at the University of Minnesota (USA) have discovered the educational benefits of social networking sites in a study. They found that low-income students are in many ways just as technologically proficient as middle- and upper-income students, going against what results from previous studies have suggested. "What we found was that students using social networking sites are actually practicing the kinds of 21st-century skills we want them to develop to be successful today," says Christine Greenhow, a learning technologies researcher in the University's College of Education and Human Development and principal investigator of the study. "Students are developing a positive attitude towards using technology systems, editing and customizing content, and thinking about online design and layout.

"Now that we know what skills students are learning and what experiences they're being exposed to, we can help foster and extend those skills," says Greenhow. "As educators, we always want to know where our students are coming from and what they're interested in so we can build on that in our teaching. By understanding how students may be positively using these networking technologies in their daily lives and where the as-yet-unrecognized educational opportunities are, we can help make schools even more relevant, connected, and meaningful.

Along with the benefits, students who use Social media tools might pay significant hidden cognitive costs. Social Networking Sites simultaneously seize and fragment our attention. They can subvert higher-order reasoning processes, including the kind of focus, concentration, and persistence necessary for critical thinking and intellectual development. Some researchers have correlated heavy Internet use with greater impulsivity, less patience, less tenacity, and weaker critical thinking skills. The need to rapidly shift from object to object online can weaken students' ability to control their attention. Prolonged Internet use exposes students to interactive, repetitive, and addictive stimuli that produce permanent changes in brain structure and function. The more one uses the Internet and Social Media, the better the brain can skim and scan. But research suggests that these gains degrade the capacity for concentration, reasoning, and reflection—in fact the very sort of critical thinking and evidence-based reasoning needed to honestly appraise the full costs of using Social Media.

Learning and research capabilities: Students have started relying more on the easily accessible information on these sites. This reduces their learning and research capabilities.

Focus: Students who get involved in activities on social media sites while studying result in reduction in their focus of attention. This causes reduction in their academic performance, and concentration to study well.

Real human contact: The more time the students spend on these social media sites, the less time they will spend socializing in person with others. This reduces their communication skills. They will not be able to communicate and socialize effectively in person with others. The employers are getting more and more unsatisfied with the communication skills of the fresh graduates due to this reason. The effective communication skills are key to success in the real world.

Command over language: Students mostly use slang words or shortened forms of words on social media sites. They start relying on the computer grammar and spelling check features. This reduces their command over the language and their creative writing skills.

2.1 Research Study

The purpose of this research study is to explore the impact of Social Media on students. A research questionnaire was designed to determine the factors of Social Media that have impact on students. Variables identified are age, gender, education, social influence and academic performance. 168 respondents that were only students were randomly selected. The study concluded that students whose age range from 15 to 25 mostly use Social Media for entertainment. 60% of male students commonly used for knowledge. Graduation students generally prefer for entertainment. From this research study it was also found that people can use Social Media due to social influence. This study determines that most of students use Social Media due to their friends and its total average is 67.3% of total sample. Students having 3.0 to 3.5 GPA (Grade Point Average) mostly use Social Media for entertainment.

	SSC	HSSC	Graduation	Master	PhD
Entertainment	0	9	26	15	1
Knowledge	1	1	18	26	3
Time Killing	0	3	15	9	0
Communication	0	3	18	19	1
Total	1	16	77	69	5
Percentage	0.6%	9.5%	45.8%	41.1%	3%

2.2 Research Findings

This research is conducted to explore the effect of Social Media and its impact on academic life and learning experiences of students. According to the results gathered from 168 respondents shown in the above table Social Media grabs the total attention and concentration of the students and diverts it towards non educational, unethical and inappropriate actions such as useless chatting, time killing by random searching and not doing their jobs. Students and teenagers mostly use Social Media for time killing and sake of enjoyment but it has been analyzed that internet use for education purpose and any appropriate task including online tutorials, online lectures and education material downloading is very good but use of internet for only Social Media is very useless perhaps dangerous.

3. Conclusion

A lot of criticism has been leveled at Social Media and the effect it has on the way students process and retain information, as well as how distracting it can be. However, Social Networking Sites offers plenty of opportunities for learning and interactivity, and if you take a moment to think about it, it’s not too hard to see how students benefit from using Social Media. As younger generations use such technology in the classroom, they remake the educational landscape.

There are so many ways Social Media has changed the world, and the education especially Distance Learning Programs are the most significant. Up to this point, Social Media has a firm place in our future, where it is hoped that the capabilities of these interactive platforms will be extended.

In summary, there are clear advantages to use social media in Distance Learning. With Social Media services, online teachers and learners can experience new and better types of communication and interaction, and they can be more connected to each other than ever before. Social Media tools help online learners feel less isolated. With Social Media technologies advancing, distance education will continuously evolve with the trend. Students are experiencing the world through more than just books and assignments; they are learning and adapting to the world using a relatively new form of communication. In a world where connections are important, graduates are coming into the workplace with a lot to offer.

3.1 Recommendation for Future

The current research has demonstrated that, if we utilize Social Media properly, it can facilitate distance and extra-curricular learning and enable students to learn outside of the classroom in an engaged way. It can help students who do not have access to adequate schooling to supplement their studies with high quality tools. Furthermore, students whose educations are interrupted regularly will also be able to access information that can bridge the gap and make transition back to school easier.

A general recommendation is that more research needs to be done about policy of Authorization of Social Media Sites. Use good judgment about content, respect privacy laws and exercise discretion in posting content that could reflect negatively on users or the Institution. Violators of this Policy may be subject to disciplinary action, up to and including dismissal from the College or termination of employment

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Social Media and Development

Enhancement of Learning for Engineers through Constructivist Methods

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Abstract

Mathematical problem solving errors occur mostly because of implementation based on ill-formulated representation - in spite of a correct computational plan. The focus of this paper was enhancement of learning through the process of understanding a problem. Visuals are a powerful means to depict cause and effect and lead to deeper learning. It can be reasoned, therefore, by adding relational, interpretive visuals to a lesson, a higher level of learning should occur. In a proposed interactive programme a student is given control of input variables and is, therefore, able to see their influence on primary aerodynamic concepts. The programme creates realistic configurations from complex abstract calculations, allowing a student to fully appreciate the value of their work. The programme was used for second year undergraduate engineering teaching and over a three-year period was monitored and improved. Student reaction to the new pedagogy was extremely positive.

Keywords: *Technology education, aerodynamics, constructivist learning, graphics.*

1. Introduction

The overall goal of science and engineering education is to provide a student with the guidance and the tools to absorb relevant information, understand scientific principles and apply knowledge gained to real-life design and problem solving. Mechanical and aeronautical engineering modules are difficult for students. For example aerodynamics requires understanding of the physics of fluid flow and its governing equations. In student feedback, many expressed difficulty with concepts, so in 2008 revision of the aerodynamics module used at the University of Limerick, Ireland, was initiated. There was a problem with transfer of knowledge and rapid, in-class retrieval of information from long-term memory; the subject heavily dependent on a plethora of multidisciplinary concepts. An alternative to teacher dominated learning situations was supplied though in-house designed software. Extensive research into the psychology of the learning process to assess enhancement of learning was completed by use of graphical user interfaces (GUI); their design procedure was studied in great detail; the phases involved were then related to this project.

Understanding may be classified as a type of explicit learning. It is one of the most areas of explicit learning as it pushes the working memory to its limits. It demands an ability to control one's thought process while reflecting on knowledge stored in long term memory - a mentally demanding cogitative activity. Difficulty in understanding and avoidance has been investigated [1]. This preference to problem solving or memorisation can lead to difficulty when changing intuitive theories. Without understanding the concepts, fresh information is added to the long term memory [2], [3], without preconceived ideas being revised and updated. This is vitally relevant to students of aerodynamics, since misunderstanding concept usually means poor understanding.

An important distinction is the difference between analytical and numerical solving of problems. While this project sees as its goal the creation of a learning tool for a mathematical equation, it does not seek to solve an equation numerically. A numerical solution is one with numerical value, i.e. enter a set of variables and an exact solution (a number) appears. An analytical solution is a demonstration of cause and effect; fluctuation in the value of a specific variable leads to changes in output. A similar idea when comparing representational and solution problem solving is described [4].

“Representation occurs when a problem solver seeks to understand the problem; a solution occurs when a problem solver actually carries out action required to solve the problem”. This is an interesting finding leading one to believe if during the learning process emphasis was put on carrying out a procedure and adhering to a set of particular rules only, depth of understanding and the meaning of the solution are lost. Therein lies the problem.

Most mathematical solution problem solving errors occur from implementation of a mathematically correct computational plan, but based on ill-formulated problem representation; the key is to understanding the problem.

A study [5] examined student behaviour and the effectiveness of education of fluid mechanics and heat transfer through computer-aided learning (CAL). The study explains how these areas of engineering brought formidable and time consuming mathematical and conceptual obstacles. Undergraduate courses proved superficial in approach, only basics, or what the author refers to as the foothills of the subjects, were touched. The problem presented here is how to ensure a student achieves a high level of understanding if so restricted. A programme was developed using an algorithm to solve two-dimensional flow problems. Examination indicates huge benefits from advances made in technology in relation to learning and specifically engineering. To take full advantage it was vital the technology be utilised correctly to ensure the learning process was efficient and effective. By employing the constructivist learning method and using graphics through technology such as a GUI, students were encouraged to actively learn as opposed to memorisation of information and facts for repetition. Other works of a similar nature include [6], [7] and [8].

2. Constructivist Learning

Constructivism aims to provide an alternative to teacher-dominated learning situations. It encourages discovery through guided and supervised experimentation, trial and error and examination. It is a middle ground between a complete teacher-dominated learning atmosphere and unsupervised student discovery. Successful constructivist learning reduces student rote memorisation of material and facts and encourages students to challenge knowledge, theories held and progress by discovering information themselves. The lecturer and student need to actively organise, elaborate on and interpret knowledge [9]; it is not sufficient to merely repeat and memorise information. Also, a student needs to learn new concepts as organised related information, not as random lists of unrelated information.

This is important when considering engineering. A student with weak understanding of a topic or engineering concept could memorise necessary information, formulae and processes to complete a problem or pass an exam. In this scenario the student has preformed to a satisfactory level, however, their level of knowledge and understanding of the topic could still be below par. Constructivist learning encourages a student to ‘create’ self-knowledge. For active experiences to occur it requires students to use previous knowledge to discover, challenge and experiment with new ideas [10]. During active learning a student creates new ideas by putting previous knowledge to use in a novel and meaningful manner. Constructivist methods are used in education today. However, they are often overlooked by educators. Lecturers, teachers and course directors may be aware of the advantages of these learning methods, but a more typical lecture style tends to dominate educational institutions. University science courses include laboratory work and mandatory coursework which aid student understanding of theory learned in class by applying that information to a real life scenario. Laboratory exercises and coursework are beneficial, but lack a constructivist approach.

Three phases of constructivist learning are emphasised: engagement, elaboration and assessment [9]. Students engage an academic task, elaborate it then assess progress towards task completion. These stages can be advanced through student interaction under guidance and supervision. The system ensures a student remains active and stimulated through the interaction with peers and the challenge of problem solving. For a student to complete a task a synthesis of available information and previous knowledge is required. An added benefit of peer interaction includes student discussion of newly formed theories, while learning as a group. Supervision is crucial as students can form incorrect theories which need adjustment to prevent formation of incorrect conclusions and task failure. The constructivist approach allows students to develop skills to be capable of solving a variety of meaningful problems and allows them autonomy and self-motivation in mathematical activity [11].

2.1 Technology and Learning

As technology advances, engineering and science industries changes. Advances in technology useful to industry can also aid education. Computers, software packages, emerging technology and advanced equipment has accelerated change and made challenging objectives achievable; why should teaching and learning of engineering not follow?

Technology is present in everyday engineering education. Examples are computer-aided design packages, computational fluid dynamics, Matlab and Microsoft Office, used as tools to aid completion of engineering tasks. These packages solve engineering problems and aid design to more readily achieve objectives. They provide a student with an alternative to teacher dominated situations and prevent memory by rote, providing an example of a real life engineering application. However, their primary goal is problem solution, not the teaching of theory. Students could learn how to use a Finite Element Analysis package and complete analysis of a structure under given loading conditions. However, they would not gain knowledge of the theories behind this as they would in, say, Mechanics of Solids.

2.2 GUI Software Review

In determining the overall effectiveness of a GUI design [12], it was found '...while it is the user's job to focus on the tasks, the designer's job is to look beyond the task to identify the user's goal...' The process of conceptual design is described as: '...in the user interface design, the conceptual level involves analysing users' needs in terms of the activities that need to be accomplished using a system and the objects and the operations which a user has to employ to accomplish the tasks...' [13]

During the initial stages of this project, research was conducted into various types of software available to design a GUI. Matlab, by Mathworks.inc, showed desired advantages. It provided superior options for handling data and superior and user-friendly when plotting data to other software; Microsoft Visual Studio has changed science and engineering. Now many engineers use Visual Studio to write programmes or build controllers with graphic user interfaces. Visual Studio interfaces are found in many laboratories and excel in controlling, co-ordinating and acquiring data from instrumentation, [14]. It is an integrated development environment (IDE) software package freely available as a download from Microsoft. The package is used to design GUIs, web sites and for online applications. Incorporated into the visual studio interface is a code editor and form designer. The code editor uses IntelliSense which is a tool to aid speeding code writing in software development. Writing code is often confusing because of volume of commands, variables and symbols to be remembered. IntelliSense works by accessing a database which has stored all commands and variables created by the designer. It works by detecting characters entered into the code and provides predictions in a pop-up menu for the user to choose, from similar to predictive text by mobile phone. The user can accept any command by pressing *enter, saving*s them typing the whole line of code. In this code editor the designer can edit properties of application such as images colours, backgrounds, visual effects and sounds, but most importantly, the working of the interface such as buttons menus, checkboxes and other controls.

3. Data Acquisition and Visualisation

A GUI was designed enabling a student to analyse and compare nine similar aerofoils and observe how their aerodynamic characteristics changed as their geometry changed. Students were encouraged to gain understanding through guided experimentation and trial and error. In this way the student put previous knowledge to use in a novel and meaningful manner. The project has developed to provide students with software that lets allows them tot test the effect of changes in variables on output. As part of the module students were supplied with software to examine the process in designing an airfoil for a particular application. Student groups were challenged to reach the best solution for a practical problem e.g. wind-turbine blade. It proved a powerful tool, enabling students to interpret course material.

For the proposed interactive programme a student was given control of input variables and sight of their influence on primary aerodynamic concepts. It created realistic configurations from complex abstract calculations, allowing the student to fully appreciate the importance of their work. The varying of airfoil geometry such as camber, camber position, maximum thickness and position of maximum thickness was carried out to analyse the effects on aerodynamic characteristics; nine airfoils with differing geometry were analysed and compared. The data obtained was portrayed using graphics, such as airfoil images and data plots, with the aid of a designed GUI. The data was then analysed and plotted with Matlab followed by coding into the user interface designed through Microsoft Visual Studio 2010. This project also used software to obtain simulated experimental data; opposed to data obtained through conventional laboratory testing. To collect data from XFLR5, a NACA 4415 airfoil was loaded into the airfoil design interface in XFLR5. With this airfoil selected in the analysis section of XFLR5, testing conditions were defined e.g. Reynolds Numbers, angle of attack range; then analysis was initiated. The nine airfoils were variants of the NACA 4415 each having one particular characteristic changed to make a new airfoil. The characteristics changed were camber, position of maximum camber, thickness and position of maximum thickness. Each variable was increased or decreased from the initial 4415 settings and analysed. Table 1 outlines the characteristic of the nine analysed airfoils:

Table 1: Characteristics of nine analysed airfoils through XFLR5

Airfoil	Camber (% chord)	At (% chord)	Thickness (%chord)	At (%chord)
NACA 4415	4	40	15	30
Aft camber **NACA 4615**	4	60	15	30
Forward camber **NACA 4215**	4	20	15	30
Increased camber **NACA 6415**	6	40	15	30
Decreased camber **NACA 2415**	2	40	15	30
Aft thickness* **NACA 4415/X	4	40	15	35
Forward thickness* **NACA 4415/Y	4	40	15	15
Increased thickness **NACA 4420**	4	40	20	30
Decreased thickness **NACA 4410**	4	40	10	30

As data was displayed in graphic form, it was also required in numerical form and the export polar function in XFLR5 was used. Using this function the numerical data was exported as .txt files. These files were then copied and pasted into Excel in order to assign separate sets of data to cells. With the data now in this form, each column could be copied into Matlab and saved as a single variable allowing manipulation of single variables and generation of desired plots. This process was repeated until all data was saved in the Matlab workspace. This was a long, tedious, repetitive process, but necessary to achieve the graphs required. With numerical data saved one could call upon any graph. Under option two the user could select a plot of either C_L vs. α, C_M (pitching moment co-efficient) vs. α or C_M vs. C_D for varying camber, camber position, thickness or thickness position for a specific Reynolds Number. For example Figure 1 showed coefficient of lift (C_L) v coefficient of drag (C_D) plot for changing camber position at a Reynolds Number (Re) of 4 000 000. By using the code, any of the desired graphs could be called upon by simply adjusting the code for the desired variables. This process was repeated until all graphs were plotted and saved as images in j.peg format. It was also necessary to obtain plots for C_{Lmax}, C_{Mmin}

(moment coefficient) and E_{max} (maximum aerodynamic efficiency) – Option 1. This was to give the interface user a graphic representation in one graph of how the lift, drag or moment characteristics of a given airfoil changed as did the camber, camber position, thickness or thickness position. Toexclude this would have made it difficult for the user to compare C_{Lmax} for two different camber positions. E_{max} is a ratio of C_L/C_D which can be graphically approximated by drawing a line tangent to the C_L vs. C_D curve from the origin. Where the line touches the curve gives an E value. This is the optimum ratio of C_L/C_D for the airfoil to operate at the given Reynolds number. Similarly it was also required to obtain plots for C_{Lmax} and C_{Mmax}. To do this the maximum values for each corresponding to each airfoil at each varied camber, camber position, thickness and thickness position were defined as new variables in Matlab..

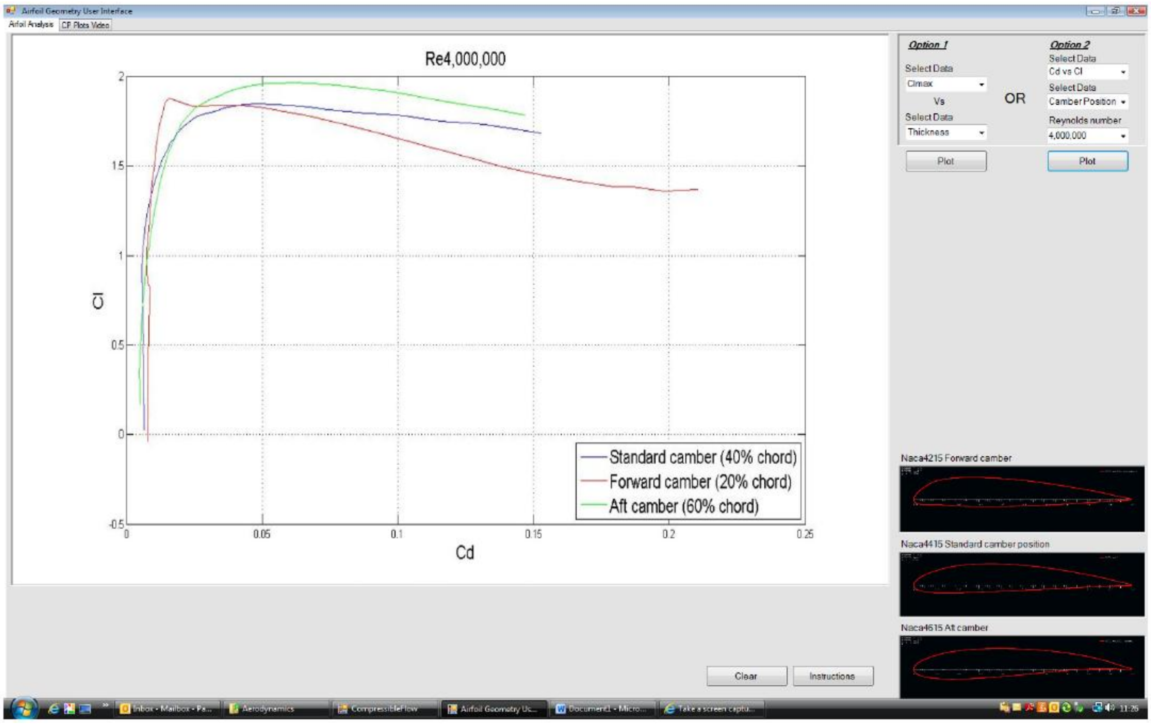

Figure 1: Plot of CL vs. Alpha for changing camber position at Reynolds Number 4 000 000

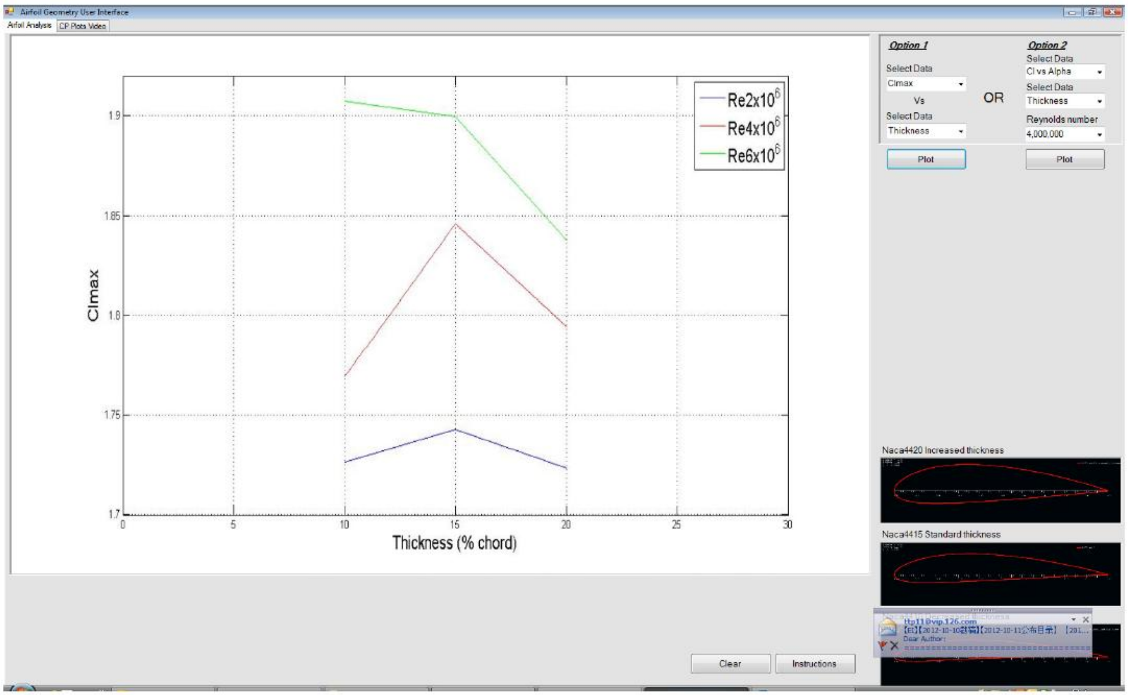

Figure 2: Maximum lift co-efficient for varying airfoil thickness and Reynolds Numbers

The GUI provided the user with a graphic image to relate information; the user had an option to view changes occurring either as graphic or numerically.

4. Methodology

Engineers in general are visually orientated, so inductive approach has reinforced student understanding of how an airfoils' performance may be altered by changing geometry and boundary conditions. Thus, a strong cognitive preference for the visual transmission of information is supported by this approach. After examining data collected for the nie airfoils generated from varying camber, camber position, thickness and thickness position from a NACA 4415, students provided observations; the GUI enabled students to understand and apply that knowledge to airfoil design.

Airfoil Camber

- Increasing camber increases the maximum lift co-efficient;
- increasing camber increases lift and consequently E_{max} increases also;
- increasing camber increases negative (nose down) pitching moment and,
- there is an increasing nose down pitching moment as camber position moves aft.

The students were asked to submit a report discussing.

1) The effect of boundary layers on the lift and pitching moment trends, at both low and high R.
2) The variation of viscous drag as angle of attack and Re change.;
3) Corrections required for a three-dimensional wing.
4) Boundary layer separation, transition and reattachment points from co-efficient of pressure plots.

Based on this improved understanding, students were then assigned a problem to solve e.g.to find the best NACA airfoil to act as a wind-turbine blade. The problemwas constrained through values defined for camber, location of camber and thickness. The Mach Number (M) and the Reynolds Number (Re) are defined by students based on literature reviews relating to operating conditions. The students were shown how to accomplish the task methodically by using their understanding of geometry and conditions of aerodynamic performance. The results demonstrated students, using the software, enjoyed solving the task. This new approach and assessment method has proved effective and has been commended by external academics.

In a 2012 report, Prof. CJ Atkin ssaid: 'I applaud the successful introduction of computational tools to allow students practical experience of modern analysis and design software to explore the complex aerodynamics of variable wing shapes. The students' work I have seen has been of a high standard and the students have clearly found the course extremely stimulating and an enormous improvement on the previous teaching.'

Students focused efforts on the process to be undertaken to solve a problem though the software, rather than the theory being memorised and complex calculations made. This resulted in an improvement in the teaching environment; encoding information taught this way enabled students to efficiently retrieve required information during class, helping them to internalise the topic and making it easier to visualise relationships between topics, apply knowledge gained and understand theory. Importantly, this inductive approach also enhanced lecturer-awareness during the class.

The effectiveness of this teaching approach was evaluated by using two methods, comparing student performance and Formative Student Evaluation of Teaching carried out by the Centre of Teaching and Learning, University of Limerick.

4.1 Student Performance

Students' performances were used to assess the effectiveness of the learning technique, see Table 2. The exams in all cases accounted for 70% of the module score and the questions were designed to evaluate learning outcomes and linked to understanding; QCA is a quantitative measure of a student performance with a QCA of 3.4 - 4.0 equating to a First; 3 - 3.39 to a 2.1; 2.6 - 2.9 to a 2.2; 2 – 2.59 to a 3rd class degree.

Table 2: Performance by aeronautical engineering students 2008 & 2012

	2008 QCA	2012 QCA	ΔQCA
Aerodynamics	2.71	2.67	-0.04
Aircraft vibrations	2.48	2.16	-0.32
Class average for semester	2.77	2.49	-0.28
Class average year end	2.87	2.61	-0.26

Comparing aerodynamics results with the same group that took aircraft vibrations it was found although the class of 2012 appeared weaker, their performance in aerodynamics was at the level of 2008. The average QCA for the modules from 2005-2012 was aerodynamics 2.51, vibrations 2.35. The same lecturer taught aircraft vibrations and aerodynamics. In aerodynamics, the average grade achieved was between a B3 and a C1 overall (ΔQCA=-0.04); for aircraft vibrations it dropped from a C1 to a C3 (ΔQCA=-0.32). The only variable to change was introduction of the GUI and the coursework. The coursework percentage of the module was 15%, as in previous years; all other aspects were 7unchanged.

From semester average QCA and end of year QCA it was found that the class of 2008 was particularly strong – on degree completion, 50% of the class obtained first class degrees; average from 1994-2010 was 20%. The performance of the 2012 class was poorer (ΔQCA=-0.26). On reviewing the second level education graduating results it was found there was a significant reduction in points scored for university entry (25%) and a drop in the number of students with a B3 or greater in mathematics (14 to 8).

4.2 Student Evaluation of Teaching

Formative student evaluation is a structured approach to obtaining feedback from students on quality of module content and delivery. It provides a valuable in-depth critical review of lecturing styles. The survey was conducted online with 10 lecturer items, eight module items, seven student items and carried out using a five-point Livert Scale. The survey was carried out autonomously and anonymously by the university; the lecturer was not privy to individual information; 26 sat exams. The response rate for both cohorts was >40%. Although sample sizes were small, trend proved valuable and used to compare student feedback about this approach (class of 2012) with a group from another academic year (2004) that did not use the approach; both courses were taught by the same lecturer. In the earlier evaluation (2004) students noted information was hard to digest' and understanding notes difficult because of myriad equations. The overall effectiveness of the module in 2012 as scored by the students was 4.4/5 (an increase of 13%). All items relating to lecturing showed a positive shift. In Figure 3 can be seen the most positive influence was on motivation of further enquiry (5/5) and interaction with students and the lecturer (4.6/5). This inductive teaching approach, introducing a real life problem and showing how it can be solved brought enthusiasm to the class (4.8/5) and led students on to the theoretical aspects of problem solving. Conceptual understanding of the subject was enhanced by constructivist methods leading to a desire to introduce these methods to other courses.

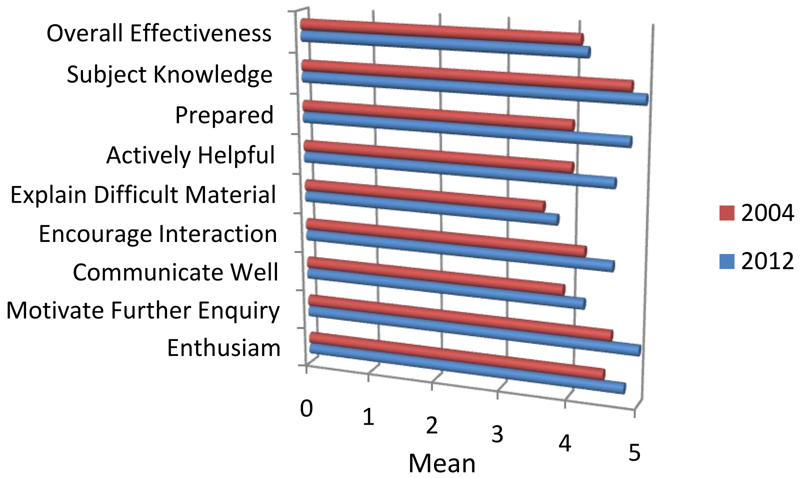

Figure 3: Formative student evaluation of teaching

Aerodynamics, feedback was obtained for the last three years to see what effect the new methods had made to course understanding from class. Comments included:

2011 *'...This project really advanced our knowledge of airfoil design - much more so than just reading about it in books. This combined with our lab using the wind tunnel really turned the screw in terms of understanding...'*

2010 *'...It would be recommended to use this type of software with any future course study as we have found it to be a great source of learning and understanding for complex concepts...'*

5. Conclusions

An examination of this study indicates huge benefits from technological advances in relation to learning and specifically engineering. By employing a constructivist learning method and utilising graphics through technology such as GUI, students are encouraged to actively learn, opposed to memorisation of information and facts by rote. An alternative to teacher dominated learning situations is supplied though specialist software. Students are encouraged to gain understanding through guided experimentation and by trial and error. In this way a student puts previous knowledge to use in a novel and meaningful manner. This inductive teaching approach, introducing real life problems and solutions brought enthusiasm to the class and led students to the theoretical aspects of problem solving. They were challenged to find optimum solutions to practical problems. It generated a motivation for further inquiry by students and created an enthusiasm for student-student and student-lecturer interaction. This confirmed constructivist theories and how social psychology affected learning. The creation of a programme which served to assist students better conceptualise airfoil design proved a favourable addition available learning resources. The investment required to replicate this approach for their areas was worthwhile as many tools employed were available for tertiary education , such as engineering software for analysis, Matlab and Excel.

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Presenter: This paper was presented by Patrick Frawley

Best Practices in Multimedia-based Education

Bringing a University Pedagogical Approach into Companies

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Abstract

This paper describes and discusses how the university pedagogical approach used in engineering education can be applied in a corporate setting. Problem Based and Project Organised Learning (PBL) pedagogical approach has been used in engineering education at Aalborg University for 30 years and this PBL structure was implemented in a Danish company which wanted to establish a learning environment, so that their employees would share their knowledge and understanding of the work processes across different departments. The pedagogical approach is described and two workshops are used as examples of the learning processes. Through facilitated workshops focusing on problem analysis and the development of solutions, the participants gained a greater understanding of the need for learning, as well as increased motivation for sharing experiences across organisational boundaries. All participants made a project and found solutions for for problems related to their work. Several of the problem solutions were implemented. The participants evaluated the process and the outcome of the workshops very as very good. Furthermore the results show that the pedagogical method which has been used within engineering education functioned very well in a practical setting.

Keywords: *Problem Based Learning. Work Place Learning. Participant Directed.*

1 Introduction

An important challenge in establishing lasting learning processes in companies involves anchoring the learning within the organisation. Traditional courses and training are an efficient way to give employees new qualifications, but it often seems as if the long-term effect is missing [1]. Traditional courses are often used by organisations to train employees so they can perform better, but in the same ways as they always have done [2]. There are several positive aspects to both traditional courses and training, but if the goal of learning is to gain new knowledge and to establish a learning culture in the organisation which supports the new qualifications as well as further learning in the organisation, it is important to use a strategy based on pedagogical theories and methods that takes individual as well as team learning into consideration [3]. We know that motivation is a huge factor in the learning process, especially for learners with few or bad learning experiences. We have been using Problem Based Learning for many years in engineering education, and have experienced its positive effect on motivation and in obtaining specific qualifications, as well as qualifications within problem solving, communication and the ability to see new qualifications and development as an important part of solving bigger and more complex problems [4, 5].

We have been involved with a wide range of different organisations, and different types and levels of teaching and learning in industry, in universities, in high schools, vocational schools, etc. In these situations, we have used different teaching strategies based on problem-based and project-organised learning approaches, and our experience is that they provide a different and improved learning outcome. We consider this learning approach an effective and motivating way to organise the kind of learning situations needed when working to establish a learning culture which is also involved in changing behaviour and strategies in companies.

When trying to establish a theoretical approach based on Problem Based Learning - PBL- [6,7], our first focal point was to introduce the importance of understanding why learning is needed, how we learn and how learning can be part of both individual and organisational development. The next focus was the role of teachers or facilitators in the learning process; at this point, we were very much aware of the necessity of focussing on structured experimentation, as it is in the cross field between reflection and experimentation that innovative processes take place [6,8,9].

This paper focuses both on individual learning and the social aspects of learning. Our aim is to discuss the circumstances under which we can expect problem based, project organised teaching/learning methods to be effective in relation to changes in attitudes and values towards learning. To be effective, the aim of the learning process must encompass more than participants/employees gaining new knowledge at the cognitive and affective levels: motivation for continuous learning should also be ensured. Our assumption is that it is important for the teacher/facilitator to have a clear pedagogical approach in order to establish learning activities to support both strategies.

The first part of the paper presents the pedagogical theory developed through the years we have worked with engineering education and training in particular, and which we will use in the learning cases. The second part of the paper presents two examples from different cases in which learning processes have been facilitated. Finally, we discuss perspectives on and the benefits of the theoretical approach used in the learning cases.

2 The Theoretical Learning Approach

The scope of our work on establishing learning processes in companies has been to create learning situations in which participants have the opportunity to develop, experiment with, and evaluate ideas for improvements that can eventually be transferred to actual, everyday work situations. Within the learning situation, it is the aim that participants will begin to develop such skills as communication and conflict resolution, problem-analysis, problem-solving and evaluation. In order to ensure maximum outcome of the learning situation, it is necessary that the participants feel secure within the learning arena. For this reason, it should be stated clearly that if it is possible to remove any negative consequences from the tests on actual productivity, “mistakes” are not only allowed but even expected when potential solutions to work related problems are discussed, tested and evaluated in either a simulated work environment or in the actual work environment. We refer to such an environment as the “learning space”. Participants should also be encouraged to view themselves (and their co-workers) as experts within their respective fields, each possessing unique ideas, talents, and skills which can positively influence the project work [10].

In this type of learning the scope is “here and now” solutions which incorporate ever changing societal values and cultures into the learning model. Employees move from something safe and known to something unknown. Because the existing culture and values may no longer be valid in the future work situation, the entire organisation must sometimes accept a completely new set of values, responsibilities and in fact, even a new organisation. To do this successfully, double loop learning is necessary [11].

The development process requires new knowledge and skills to be obtained, and a new level of understanding and attitudes to be adopted. A learning process that involves the participation of some or all members of the organisation, will best ensure that the necessary resources (knowledge, skills, abilities, values, attitudes, and practices) are present in the future work environment. They do not necessarily need to participate in the same workshop, but should have the same understanding of the learning approach.

Cognitive knowledge on the level of understanding requires that a learner goes through a reflection period. Reflection is even more important when the required learning encompasses a person’s affective development. The theoretical approach for the learning processes we apply takes advantage of experiential learning combined with reflection [6].

When working with improvement activities, it is very important for participants to take responsibility for their own learning process and to ensure that their learning is conducted in the context of real work issues: the participants themselves must select and formulate what they need to learn by analysing and offering solutions to existing problems from their work situation. This may be a facilitated process in the beginning. All aspects of the organisational environment, including the company culture, political processes, and management style will dictate the possibilities available for the learning possibilities to a large extent. Because of these unpredictable forces, teachers and facilitators must be flexible and willing to make modifications to their plans for the learning and teaching processes.

The design and planned learning activities are very context dependent, varying in form and content according to the type of learning expected and the problems, goals, and results desired by the management of the organisation. The primary condition for the selection of a problem to be included in the learning process is that it is based on a work-related problem that is relevant to the participants in an area in which they and the organisation have an interest in establishing, improving or changing something.

The learning process, as we conduct it, is based on a model where there are three concurrently operating processes: a number of participants actively working together as a group; the group identifying a work-related problem to serve as the focus of their project, or the management presenting a problem for which they want a solution; and a learning process which supports the awareness and development of group problem-solving skills. The group and teamwork should, for the most part, be centred on the project work and be related to the participant's normal work functions (see figure 1).

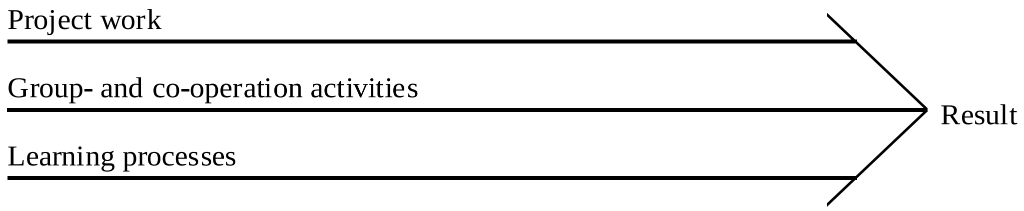

Figure 1 illustrates the 3 parallel tracks which are dealt with in the learning process

The practical arrangement of the learning process is also context dependent and will be determined by a great many factors, including the resources the organisation can allocate to the activities in terms of time for planning, space for participants to meet, and the duration of time allowed for the learning, and the technologies to support the learning (e.g. iPad, laptop etc.).

As previously mentioned, the theoretical approach on which the workshops was based was taken from Schön's theories about the reflective learner [12], combined with Kolb's learning cycle [13], which in the interpretation of Cowan [14] consists of four phases: 1) experience, 2) reflection, 3) generalisation, and 4) testing. In essence, this approach involves facilitated pre-planned reflections aimed at supporting the learning process. In other words, the workshop participants were facilitated in considering their previous experiences and the consequences (e.g. problems that had arisen) and the context in which these experiences occurred. Cowan [14] considers reflection to be the central issue in the learning process, which is why he also describes his learning concept as "reflective learning". Schön [12] distinguishes between reflection related to action, and reflection related to experience, described as reflection-in-action and reflection-on-action. These types of reflection are mostly retrospective in their attempt to analyse actions for the purpose of using the gained experience and the deducted theories in future learning situations. Cowan then adds a third learning distinction, reflection-for-action which is reflection typically made before starting a project. Our learning approach, based on Schön, Kolb, and Cowan, thus, encompasses three pre-planned reflection loops [14, 15]:

- Reflection – for – action
- Reflection – in – action

- Reflection – on – action

The workshops in this study were based on a model in which the following three processes operate concurrently:

- Project work: Group identification of a work-related problem to serve as the focus for a project (problem-based project)
- Group work: Participants actively working together as a group (group organised project work)
- The learning process: Learning processes involving awareness of meta-learning which supports development of individual and group problem-solving skills (learning how to learn), and a strong focus on pre-planned reflections (see fig. 1).

The design and context of the workshops were very context dependent. All aspects of the organisational environment, including the company culture, political processes, and management style largely dictated the possibilities available for the workshops. One significant way in which the environmental conditions affected the learning process concerned the practical arrangements for the workshop. The resources the organisation could allocate to the activities in terms of time for meetings, space for the participants to meet, and the duration of time in which the workshop would be permitted were all factors that had a bearing on the course of the workshops, but awareness and interest from management was also important. Management should actively show that the learning is needed and that they appreciate the employee's effort.

3 Empirical Background

Half of the employees (200) in the case company worked in production on a three-shift basis. The shifts were driven by a desire to be recognised as the best shift within their respective departments. The way in which the shift members developed knowledge, shared experience within their respective teams, and had a strong team identity is representative of what Wenger [16] refers to as 'communities of practice'. According to Wenger a community of practice exists when individuals with regular interaction share a desire for learning, and purposefully direct their behaviour so as to support group learning. Legitimate peripheral participation [17], or the process by which newcomers are brought into the community of practice, was accomplished through on-the-job training of new shift members.

On the other hand, there was a strong tendency for the shifts to compete against each other, and each shift claimed to be the best. Due to both the competition to be recognised as the best shift within a department and/or in the production facility, there was no sharing of knowledge or experience between shifts. For this reason, the individual shifts had become extremely isolated and they felt it was difficult, if not impossible, to obtain support from the other shifts or departments in the company. It was also very difficult for the shifts to cross the border to other departments when they had to ask questions or to solve problems which included a common understanding of the situation. So the company was characterised by isolated shifts/teams and very little communication and understanding among the different departments. While the focus on establishing communities of practice within each shift enabled learning and knowledge sharing within the shifts, it thus proved to be counterproductive in terms of supporting the type of learning to which management aspired.

The question was how to establish an understanding among the employees and middle management of the organisation as a whole or as a team of teams, where the sharing of knowledge and experience would be of vital importance. How could learning processes be designed within the culture, without ruining the positive situation related to communities of practice, and also be an attempt to break through the borders created by those strong communities?

4 The Process and Outcome of the Workshops

To establish the learning spaces, workshops were designed for all teams, shifts and departments as well as for the management. The general approach to planning the workshops followed the pedagogical approach as described in the previous chapter. The activities planned for the workshop also relied heavily on the idea of shared visions and common mental models developed by Stacey [18].

Participants in the different workshops formed groups and worked with specific problems that they chose themselves. These were work-related problem that served as the focus for their project, or problems presented by management for which a solution was required. The project periods could differ according to the goals of the learning.
The size and duration of the workshops varied from 5 – 20 participants and from a few hours to 3 days, with additional time for project work.

4.1 Workshop 1

Duration: three full workshop days + time for meeting with facilitator (participants used breaks or spare time for project work)
The learning goals were that participants should be able to establish, plan and carry out a project according to PBL principles, and the final results should be presented for and acknowledged by the management.
Participants were introduced to the pedagogical model: how to work in a group, how to organise a project, how to choose a problem, how to analyse a problem, and how to design and test solutions. Participants also learned how to evaluate and present their solutions. The workshop was a mixture of lecturing, exercises and work with the projects. The groups were facilitated during the project period: each group had 1-3 meetings with a facilitator, and they were allowed to contact the facilitator and ask questions via email or telephone. The groups reflected on the progress of their project during the meetings with the facilitator, and potential issues they wanted to discuss. They also reflected on the cooperation and communication in the group as well as the learning process. The last subject was rather difficult until a game about aspects of theoretical learning based on the Kolb learning cycle was developed [19].

The learning process was designed so that participants would learn to analyse their chosen problems, to design experiments, to generate and test solutions, and to evaluate tested solutions in terms of negative and positive consequences, before presenting their project to senior management. The groups found it hard to start using time for reflection. They stated that they always did what they could to solve problems. However, in the last part of the workshop, they became used to reflection and the word became a part of their daily vocabulary. One participant suggested, "Let us do a little reflection before we answer", and another said: "We have always been eager to solve problems and help each other, and when there was a problem we all ran to the place with a shovel, but what was needed was a screwdriver. Now we know that we didn't pay enough attention to analysing or reflection".

Another part of the learning process involved attempting to do something in another and better way. The participants did in fact have many ideas about this. The challenge was to learn to test and debate why particular ideas were worth trying. They had to learn the different ways of formulating and testing ideas according to Schön [8]: to ask the question "What if?" This tool was a great eye-opener for most of the participants. One participant stated, "In the 'old days' we just got an idea and sometimes we got the opportunity to try it out. Sometimes it functioned and sometimes it didn't: it was trial and error. But now we are much more aware of which experimental design we are going to choose, and the importance of having a test design, so we can convince other colleagues and management."

By the time the workshop was concluded, the groups had all formulated a well-analysed problem with solutions that had either been tested or for which there was a plan for testing. Some of the projects were even implemented in the organisation before the workshops were over.
At this level, the PBL learning experience could be seen as a success.

The participants evaluated their learning and project process and outcome of the workshop as very good.

4.2 Workshop 2

Two half days workshop + time for project work.
The company had a major problem concerning lack of communication between the departments and the understanding of each department's problems.
On this background it was decided to make a special workshop with the aim of crossing the borders between departments.
The goal of the workshop was to define the problems and to come up with solutions which could be implemented immediately.
This started a workshop for representatives from each department, where a 'reflection for action' plan involved the following problems:

- Where are the borders to other departments?
- With which departments do we have to be in close contact?
- What important information and knowledge is needed from the different departments so they understand our needs and we understand their needs?
- What does each department expect from the other departments and what are the departments able to deliver according the common goals?

This 'reflection for action' surprised all participants, including the representatives from the management group. They suddenly recognised why it was sometimes problematic, for instance, to get timely test results from one department to another. Another department also found that they had to be much more specific when they asked for information that should be useful for a planning task. One department realised that they had not known what support they actually could get from the IT department until they had participated in the workshop.

After the workshop with department representatives each department began to formulate a project to solve. They did their project work according to the previously learned PBL method, and quite quickly had solutions to be tested and implemented in their daily work. These included projects on an improved planning system for the production process and the planning department, and projects about how to share knowledge and information between three departments. One project was about efficiency in the laboratory, about which there had always been complaints because all departments wanted their tests to be prioritised as number 1. When the different departments worked together on a solution for the laboratory they developed a system of prioritisation and realised that an extra laboratory assistant was absolutely necessary. Management agreed with all the projects, and they were all implemented.

The participants evaluated the process and the outcome of the workshop to be very good, and they had several new project proposals, which that wanted to work with.

5 Conclusion

The aim of this paper was to present experiences in applying the PBL approach in a company setting, for the purpose of developing a learning environment characterised by the sharing of knowledge and experience 'across the borders' and between shifts and departments. Through workshops targeting problem analysis and problem solving, members of the organisation successfully developed and implemented a number of projects. Through this process, individual shifts that had been successful in adopting communities of practice behaviours related to the exchange of learning experiences, gained a greater awareness and appreciation for the work processes occurring in other departments or parts of the company. For the first time, they could also see that keeping knowledge within the team or the department only could be detrimental for the other departments, and that this would inevitably lead to poorer performance for both shifts/teams/departments. They were thus able to recognise the negative chain effect of keeping knowledge within the boundaries of the individual shift/team. This awareness is vital to the establishment of a learning environment, so that problem solving efforts are no longer hindered by functional boundaries, and learning and the exchange of experience can benefit all areas of a company.

Perhaps more importantly, participation in the workshops provided employees as well as members of senior management with an awareness of the importance of learning for the survival and success of the organisation. Because all the workshops were based on the PBL approach, using concrete tools and methods to analyse and solve problems relevant to the employees' own work situations, the expectation is high that employees will be able to continue their efforts long past the completion of the study. During the project presentations the participants explained the problems to management, stating that they would like to continue to work on such projects so they could find better ways to share knowledge and experiences with the purpose of functioning better. In this process, the borders were very clear, but the teams were able to cross them as they continued to work together with other teams or departments. Establishing meta-learning processes gave the employees new identity and self-assurance. They became proud of being able to create knowledge that was important for other departments and the whole organisation.

The role of senior management, as well as middle management, in this change and learning process was also shown to be crucial for the success of the workshops. As soon as the senior management showed their interest through their attendance the participants motivation increased. Senior management's additional learning about the PBL method was very much appreciated, and they hoped to continue with this process in new projects.

Although the focus of this paper is not specifically on engineering education, the methods by which the study presented here were derived directly from the PBL approach to teaching and learning as used in the Departments of Engineering and Science at Aalborg University in Denmark. The two authors of the paper have extensive experience in using the methods within an academic context, but feel that gaining experience in a practical setting has enriched subsequent teaching experience. The teachers have been able to provide real world examples of how PBL can be applied in different settings, and this is meaningful for students concerned with the relevance of certain teaching practices in their future careers.

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Presenter: This paper is presented by Lise Busk Kofoed

Combined System for Management of Formation of Competences of Technical University Students

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Abstract

Modern Russian system of higher education is based on development of competences in various fields of studies. There is described a combined system of management of technical university students' competences. The system was developed on the base of situational theory. Student is represented as a control object which behavior is defined by individual characteristics and input variables measured by the special methods. Teacher having information on input and output variables selects and uses the management algorithm U corresponding style and methods of education. Development of the curriculum is an important step in building students' competences. It is necessary to define correctly interrelation of the subjects and to validate the importance of each subject in development of the final knowledge and skills got by the student after the whole process of education. Expert method is used for it.

The method was successfully used for the Bachelor curriculum in Mechatronics & Robotics at Yury Gagarin Saratov State Technical University.

Key words: *Competences, management system, technical university, evaluation of students' knowledge and skills.*

1. Introduction

Competence, as a generalized characteristic of the individual, determines the ability to use the potential (knowledge, skills, experience and personality) to be successful in a particular area. In the framework of the Bologna process competence is defined as "the individual's ability to realize the characteristics of knowledge and experience in the successful operation with a high degree of self-regulation, self-esteem, flexible and adaptive response to the dynamics of the circumstances and the environment" [1].

In Russia higher education is regulated by the Federal Educational Standards (FES). According to the FES university's graduate should possess a number of general cultural (GCC) and professional competence (PC). To implement the educational paradigm in education it is proposed to increase the time for independent and practical work for students to stimulate creative learning actively. For bachelor degree programs GCC defines the "capacity to possess culture of thinking, the ability to synthesize, analyze information, goal setting and choice of ways to achieve it". For Master degree programs GCC are distinguished by ability and readiness of graduates for independent learning, the acquisition and use in the practice of new skills and knowledge, including areas which are not directly related to the scope of activity.

Most of Human Resources of Russian & international companies use building of competencies model in the selection of personnel, for the evaluation of activities, for training and development of staff. Methods for evaluation of competences [2] include interviews (so called "assessment center"), 360-degree feedback (also known as multi source assessment), psychological testing, role-playing games (to assess the social, psychological competences) and the method of case studies (case-method).

Formation and comprehensive assessment of the level of competence of students at the educational institutions is carried out in the framework of the objectives of the educational process in the form of certification [3] , based on the score-rating system [4] , the organization of the educational environment and design that detects and diagnoses personal potential, intellectual, professional and creative ability of students [5] [6], as well as expert evaluation and self-evaluation for compliance with the requirements [7] [8]. In Russia the quality of the university specialists is evaluated from the standpoint of the system and the competence-based approach [9].
The structure of competence includes cognitive, functional, value, motivational, emotional and volitional components. The cognitive component is the knowledge and experience, functional one - the skills, value is generated as a ratio, the direction in the activities and key emotional and volitional self-regulation is, strong-willed actions of the subject, characterized by the presence of "internal intellectual Plan ", which organizes existing human impulses towards formation of steps to the achievement of the goal. From this point of view, assessment of competence appropriate to define a strong-willed as part of a person's ability, manifested in the conscious regulation of the activities for the implementation of the actions of readiness and desire for her to achieve the goal and control the formation of the other components of competency.

Improving the efficiency of the educational process associated with the psycho-physiological characteristics of the students must focus on the personal qualities of students [10]. Depending on them one must chose the corresponding style of managing the formation of competencies developed on the basis of the situation theory [11].

That’s why it’s necessary to create a combined management system of skills formation with the use of psychological techniques and tests, which serve as the basis of volitional component and the properties of the nervous system.

2. Management system for building of competences

It is proposed to create a management system to build skills of engineering students of the university on the base of the control theory (Fig. 1).

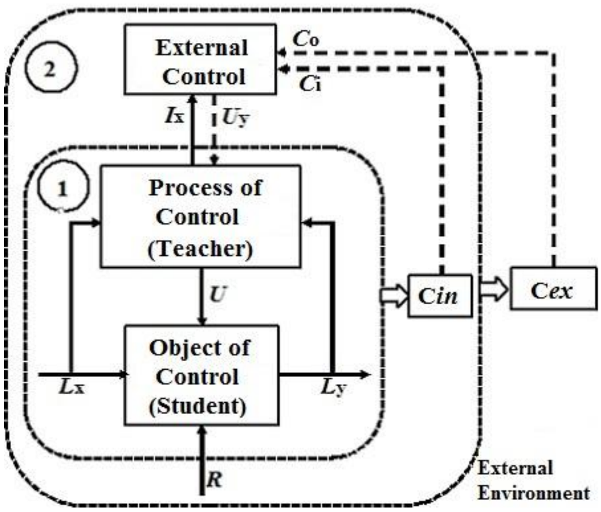

Figure 1. The scheme of the formation of the combined management competencies.

Object of Control is student, whose behavior in the learning process is determined by the individual characteristics and the input variables *Lx* (initial level of development of competences), computed using the forms of control of cognitive and functional components (CFC) competencies, and testing methods like interviews, observations, motivational, emotional and volitional components. The measurement results can be quantitative and qualitative.

Cin - internal consumer, *Cex* - external consumer. The output variables *Ly* (acquired level of development of competences): cognitive, functional, value, motivational, emotional and volitional components. Levels of formation of cognitive and functional components (CFC) are calculated using the forms of monitoring and interim evaluation of students' knowledge.

To assess the CFC there was developed a system based on the use of expert data on the level of participation of each subject of the curriculum in formation competencies for the evaluative, motivational, emotional and volitional components. The system uses method of so called developing cooperation, which is characterized by setting goals that are difficult to perform on an individual basis and therefore requires cooperation, i.e. association of students with the distribution of roles in the group.

The teacher (or system) who has information about the input and output variables, preselects and uses an algorithm to control *U*, corresponding to the formation of the style of management of competencies to the control object by using certain techniques and forms of education. The activities of the teacher are performed with the influence of external control U_y defined by FES towards training, curriculum, schedule of the education, courses content, quality management system of the university.

In addition to controlling the formation of competence at level 1 "teacher - student" (internal control system) it is necessary to check the activities of the control points periodically (academic sessions, practice, labs, seminars) and also take into account the influence of environmental factors. Quality management departments at the university fulfills external control of the quality by means of the quality managers. So one get the system input data *Ix*. *Ix* includes data about the input *Lx* and output *Ly* variables which characterize level of formation of competences, requirements of internal (*Ci*) and external (*Co*) consumers.

The proposed system of control of the formation of the combined skills can move the focus from a subject- side of education to the competence aspect of the educational process.

3. The procedure for managing the formation of competencies

For the definition of for model of formation of the competences we introduce a complex criterion *W*, requiring the using of management style *U* in order to achieve the maximum level of competence in a given time *t*:

$$W = W(L, U, t) \rightarrow max, \qquad (1)$$

taking into account the disturbance introduced by the input level of development of competence *Lx*, individual characteristics of students where: $L = M(Lx, P, U, t)$.

Management of formation of competencies: $U = U(L, P, t)$ is determined on the basis of an iterative procedure consisting of the following:

1. Target external control *Uy*: $Uy = Uy(Ix, Ci, Co, t)$.
2. Defining the properties of control object on the basis of analysis of the characteristics and subsequent grouping of students: the contents of the input *Ly* and output *Lx* variables, individual characteristics of the student *P* using expert assessments.
3. Creating a competence model of the control object: $M = M(Lx, Ly, U, P, t)$.
4. Formation of a knowledge base for the heuristic determination of control *U* according to the chosen style of management.
5. Checking the adequacy of the competence model and heuristic optimization procedure. Depending on the result the previous operation can be repeated.

4. The selection model management style formation of competencies

The basis for the creation of management styles served as the model of maturity performers, proposed by Paul Hersey and Kenneth Blanchard developed in the framework of situational leadership theory [11]. According to the theory the leader can choose one of the 4 styles of management: an explanation, persuasion, participation and delegation.

Speaking about higher education teacher, as a person who takes a role of the administrative decision maker (DM) chooses the style of managing the formation of competencies of students depending on their level of maturity. To do this, the system should be modified and adapted to the field of studies. The level of maturity of students is characterized by strong-willed properties that are investigated with the use of psychological techniques and tests. There are discovered 8 levels of maturity which are used for one of the six styles of management competences formation (Table 1).

Table 1. Styles of control the formation of competencies level.

Maturity of the student	Management style the formation of competence
Research (Rs)	Democratic (Dm)
Productive (Pr)	Cooperation (Cp)
Reproductive (Rp)	Mentoring (Cc)
Declarative (Dc)	Legislative (Dr)
Practical 2(Pc2)	Management oriented by goal (Mg)
Practical 1(Pc1)	Management oriented by task (Mo)
Cognitive (Kn)	Mentoring (Cc)
Initial (B)	Legislative (Dr)

Stages of development of model for choice of style formation of students' competences are:
The final evaluation of the model *P* (output variable) showing the maturity of the student is evaluated on the characteristics (input variables): the ability to set the goal independently - *X*; independence in achieving this goal - *Y*; desire to take responsibility for the decision - *Z*. The variable *X* is estimated by the following composite indicators: x_1 - the level of subjective control; x_2 - a synthetic way of thinking; x_3 - idealistic way of thinking; x_4 - a pragmatic way of thinking; x_5 - analytical style of thinking; x_6 - realistic style of thinking; x_7 - style self-regulation of behavior (the overall level of self-control); x_8 - scale of competence over time, x_9 - scale support. Variable *Y* on particular indicators: y_1 - the level of subjective control; ...; y_6 - realistic style of thinking; y_7 - style of self- conduct (the general level of self-control); y_8 - scale of competence over time, y_9 - scale support. The variable *Z* in components: z_1 - the level of subjective control; z_2 - achievement motivation; z_3 - a synthetic way of thinking; ...; z_7 - realistic style of thinking; z_8 - style of self-conduct (the general level of self-control); z_9 - the scale of competence over time, z_{10} - scale support.

The variables $x_1 \div x_9$, $y_1 \div y_9$, $z_1 \div z_{10}$ and *X*, *Y*, *Z* are measured at the corresponding scales. For example, variables x_1, y_1, z_1 scale: Ext - external locus of control, Int - internal locus of control. The variables $x_2 \div x_6$, $y_2 \div y_6$, $z_3 \div z_7$ - scale: N (not used), PD (persistent disregard), Ign (moderate ignoration), ZN (excluded from consideration); Mp (moderate preference), Sp (strong preference), Ua (always used); z_2 - scale: Sf (avoidance of failure), Ss (striving for success); $x_7 \div x_9$, $y_7 \div y_9$, $z_8 \div z_{10}$ - scale: L - Low, H - high; z_2 - scale: Mf - motivation of avoiding failure, LD - the lack of dominance over one another motivation to achieve success and avoid failure, Ms - motivation to achieve success; *X* - scale: A - able; NA - is not able; *Y* - on the scale: Ind - independent; AInd - unable to be independent; Z - on a scale: Wh - wishes; NWh - does not want wish.

When building a model it is necessary to build a classification of input variables and a derivation tree on its base . Hierarchy of indicators corresponds to the system of relations:

$P = P(X, Y, Z)$,

$X = X(x_1, x_a, x_7, x_b)$, $x_a = x_a(x_2, \ldots, x_6)$, $x_b = x_b(x_8, x_9)$,

$Y = Y(y_1, y_a, y_7, y_b)$, $y_a = y_a(y_2, \ldots, y_6)$, $y_b = y_b(y_8, y_9)$,

$Z = Z(z_1, z_2, z_a, z_8, z_b)$, $z_a = z_a(z_3, \ldots, z_7)$, $z_b = z_b(z_9, \ldots, z_{10})$.

The acquired knowledge about relations are given in the form of a matrix. An example of the matrix of assessment of the level of maturity of the student P is presented in Table 2.

Table 2. Example of knowledge about the relations.

X	*Y*	*Z*	*P*
Able	Independent	Wishes	Rs
Able	Independent	Does not wish	Pr
Able	Unable to be independent	Wishes	Rp
Able	Unable to be independent	Does not wish	Dc
Not able	Independent	Wishes	Pc2
Not able	Independent	Does not wish	Pc1
Not able	Unable to be independent	Wishes	Kn
Not able	Unable to be independent	Does not wish	B

Corresponding matrices are built for all positions *X, Y, Z*. Maturity levels are defined as: p_1 - initial; p_2 - cognitive; p_3 - practical 1; p_4 – practical 2; p_5 - declarative; p_6 - reproductive; p_7 - productive; p_8 - research. Each group of lines shows a conditional statement that links the values of the input and output variables. For example, the condition of the research level p_8 is a statement of Production type:
IF (X = A) and (Y = Ind) and (Z = WH) TO $P = p_8$.

5. Assessment of the level of formation of students' competences

The curriculum is a set of disciplines separated in time (by semesters). It is important to determine the relationship of disciplines and competencies and to assess the degree of participation of the disciplines in formation of cognitive and functional components (CFC) competencies. To do this we used the expert method and developed algorithm of collecting and processing data on the expert assessment of the level of participation of discipline in cognitive and functional competences. As an example, using the list of subjects from the Bachelor curriculum of full-time study in "Mechatronics and Robotics" and a group of competencies as requirements of the Federal Educational Standard for this field of study. Steps of collection and processing of expert data:

1. The experts assessed the degree of participation of the discipline in the formation of CFC competence. The degree of involvement was assessed on a scale from 0 to 1. Subjects that have the largest value of participation in the formation of the competence of CFC, a score is one that is not participating - a score of 0, the other subjects - rated between 0 and 1, depending on the extent of their participation in the formation of CFC competence.
2. Checks the consistency of the views of experts. Below there is the information on expert assessments of the degree of participation in the formation of disciplines CFC professional competence (PC1). The coefficient of concordance is calculated (Table 3) according to the formula proposed by Kendall.
   W = 12S/(m2 (n3 - n))
   (2)

Table 3. Calculation of the coefficient of concordance/

Number of the subject	Assessment made by the expert				∑ of the ranks	Deviation from mean	squared deviation	v_{DiKi}	Median of the ranks	q_{DiKi}
	1	2	…	7						
1.	0	0,1	…	0,1	0,2	-2,1	4,3	0,002	0,05	0,002
2.	0,1	0,2		0,3	0,9	-1,4	1, 9	0,008	0,25	0,009
…				…						
50.	1	1		0,3	3,3	1,0	1,0	0,028	0,76	0,026
51.	1	1		0,3	3,3	1,0	1,0	0,028	0,76	0,026
							S=6497,4	∑=1		∑=1

The coefficient of concordance: *W* = 0,012. Produced by the computation of the concordance coefficient by (2) taking into account the related estimates (equal ratings): *W* = 0,012. The results of calculations show inconsistency in the views of experts. In order to test the coherence of expert opinions and eliminate the influence of extreme opinions there is used the method of medians. We calculate the median and defined weighting q_{DiKi} for each subject. The results show a limited impact of extreme opinions of experts: v_{DiKi} and q_{DiKi} vary within [0, 0.005] what is not reflected in the final result - the level of formation of CFC. The independence of the views of experts participating in the survey guarantees the evidence of their objectivity.

3. The calculation of the weighting factor of subjects on the level of participation in the formation of the subject's CFC competence, taking into account the opinions of all the experts is calculated as follows:

$$v_{DiKj} = R_i / \sum_{i=1}^{n} R_i \tag{3}$$

Where $v_{D_iK_j}$ - the weight of the level of participation in the formation of discipline D_i's CFC competence, R_i - the sum of ranks for the i-th subject, the total sum of the ranks in all disciplines - $\sum_{i=1}^{n} R_i$. And the sum of the weights of all subjects is 1.

4. Assessment of the overall level of formation of CFC. The level of formation of CFC KF_i is calculated as follows:

$$KF_i = \frac{\sum_{i=1}^{n} v_{D_iK_j} m_{D_i}}{n} \times 100, \tag{4}$$

where $\sum_{i=1}^{n} v_{D_iK_j} m_{D_i}$ - the sum of the products of weights and estimates of the disciplines, n - number of disciplines, m_{Di} - the final assessment of the discipline .

Single scale of assessment of the level of formation of CFC is defined from 0 to 10. The intervals are defined as: CFC is not formed [3.9, 5.8), low level of [5.8, 6.8), below average [6.8, 7.8), average [7.8, 8.8), formed CFC [8.8, 10]. Level CFC is considered to be formed and the low level of development of CFC is shown in Figure 2.

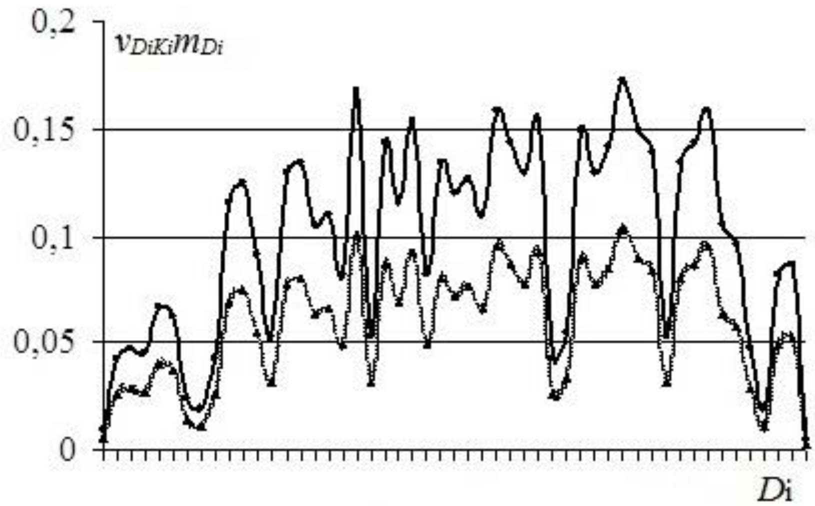

Figure 2. Comparative diagram of the level of formation of professional competence CFC.

The process of formation of competence occurs continuously during education. Therefore, for the control of formation of the competence the assessment system is developed by the formula (4) with the corresponding scales of assessment. For some subjects it is the level of formation, for blocks of subjects (per semester, per academic cycles) - grading scales. For example, for the subject "History" with a weighting factor for the formation of the competence of 0,002, there are defined levels of evaluation: not formed - 0.3, low - 0.6 average - 0.8, is formed - 1.

This approach to competency assessment demonstrates the process of formation of competence which allows to manage them.

6. Conclusion

There is described the developed combined system of management of formation of the competences of the students of technical university. The system uses experts' evaluation as together with definition of students' psycho-physiological characteristics. According the developed system the competence is determined as a set of interconnected and interdependent structural components.

The use of expert evaluation, situational theory, psychological techniques allow to take into account the human factor in the formation of competencies, in particular, taking into account the characteristics of strong-willed students allows the teacher to organize student-based learning. The formation of skills combined with the use of management strategies increases the effectiveness of the formation of competence: as the relative increase in the level of formation of competencies of students enrolled in "Mechatronics" was 55.6% and for the control group that did not apply the appropriate management style - 41.5% . Thus, the increase in performance relative to the control group was - 14.1%.

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Towards a Model for Motivating Mobile Learners: An Extension of the ARCS model

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Abstract

Motivation has generally been considered to be an important factor in student learning and achievement. The purpose of this study was to determine if Mobile learning technologies have an inherent motivational effect on learners. Accordingly, insufficient attention has been dedicated to understanding the various ways of assessing student motivation using mobile learning technologies. This research contributes to the student motivational discourse using mobile learning technologies. Drawing on John Keller's ARCS model, mobile learning factors that promote students motivation to learn were established by exploring the pedagogical application of WhatsApp mobile instant messaging. An application of mobile instant messaging that run on handhelds, WhatsApp, was adopted for two Information Technology courses at a South African University with view to heighten student motivation to learn. The research population included Information Technology Bachelor of Technology degree (BTech) and Diploma students registered for Advanced Internet programming and e-commerce module; and Information systems module respectively. The research site is a University of Technology in South Africa. To supplement lectures and the institutional learner management system (E-Thutho) academic resources, WhatsApp, was adopted to allow for synchronous and asynchronous interaction. The lecturer required students with Web-enabled devices (smart phones, PDAs, iPhones) to download WhatsApp and form consultative clusters (interaction groups) comprising of 7-10 students per cluster in addition to the lecturer. Data were collected from 223 respondents from the two classes using a self-completion questionnaire comprising of Likert-type items. Data analysis was performed using a statistical package, SPSS version 19. The findings of the study suggest that Attention, Relevance, Confidence, Satisfaction, and Social Influence are motivational factors that promote intentions to use mobile technologies for academic purposes. Furthermore, the hypothesized model was found to be valid on assessing motivation for mobile learners. Social Influence and Facilitation Conditions constructs were adopted from the Unified Theory of Acceptance and Use of Technology (UTAUT).

Keywords: *Motivation, mobile learning, Virtual learning, ARCS, UTAUT.*

1. Introduction

Stakeholders in the educational arena acknowledge the impact of mobile learning facilitated by its capability to support seamless learning spaces, marked by continuity of the learning experience across different environments. Through mobile learning initiatives students enjoy the benefits of learning in formal and informal contexts; individual and social learning; synchronous and asynchronous learning, leading to 24x7 access to learning material [22]. These emerging technologies are capable of integrating individual and social learning through mobile social networking discussion forums to bring to the students the situated mobile learning experiences that take into account both the students' everyday tasks and socio-constructivism [21].

Several institutions are embarking on mobile learning implementation into their courses; many are concerned with establishing aspects that influence effective learning as such findings are valuable to those institutions' planning emerging technologies strategies [14]. Most previous studies on mobile learning focused on investigating students' experiences with specific aspects of mobile technologies aspects, e.g. collaborative learning, ubiquitous learning, or certain characteristics of mobile learning technologies [1]. This research corroborates previous studies' views that, little is known about the key factors that motivate users to participate in adopting mobile technologies for learning [14]; [10]. This article reports on an empirical research study to explore factors that motivate mobile learners to use mobile technologies for learning. The study population included BTech and third year registered Information Technology students at a University of Technology in South Africa.

2. Problem Statement

Despite the potential for mobile technologies to foster effective learning, insufficient studies have been conducted to establish factors that promotes students' motivation in these cyber spaces. The problem statement for this study reads: Insufficient frameworks within the mobile learning environment leads to inadequate knowledge on factors that influence mobile learners to learn.

2.1. Research Questions

1. How can WhatsApp mobile learning motivate tertiary students to learn?
2. What is the effectiveness of the ARCS model in establishing factors that influence motivation within the mobile learning platform?

3. Theoretical Framework

[7] has developed a four-factor theory to explain motivation. The first is attention (A), the second relevance (R), the third confidence (C), and the fourth satisfaction (S). The model also contains strategies that can help an instructor stimulate or maintain each motivational element.

3.1. Attention Factor

A student's attention has to be aroused and sustained. This category also addresses aspects that relate to curiosity and sensation seeking among the students [7].
Strategies
Perceptual Arousal: This strategy entails that an instructional delivery method should be exercised by the use of novel, surprising, incongruous, or uncertain events in an effort to gain and maintain student attention [8].
Inquiry Arousal: under this ambit, instructional delivery should inspire information seeking behavior among students. Inquiry arousal not only posing but also encourage students generate questions, or a problem to solving purposes [8].
Variability: It refers to mechanism suitable for sustaining student interest to learn through the use of multiple elements of instruction [7].

3.2. Relevance Factor

Subsequent to the gaining of student's attention, strategies should be put in place to ensure that a student understands how the given material relates to his or her interests and goals. Students' perception that learning content is useful in achieving their goals, has potential to motivate them to learn [7].
Strategies
Familiarity: It involves using examples and concepts, which students can relate to using their own experiences and values. Students should foster understanding through these examples and concepts familiar to them [8].
Goal Orientation: Provide statements or examples that present the objectives and utility of the instruction and either present goals for accomplishment or have the learner define them [8].
Motive Watching: It promotes teaching using teaching strategies that suit the purpose profiles of the students [8].

3.3. Confidence Factor

Students should possess a sense of success while working on a task. Failure to possess this sense has potential to leave a student limited interest to continue working on a task. Sense of success among other things promotes students confidence to learn. However, possessing a sense of success should not guarantee success; otherwise if it guarantees success then students will lose interest since the task will lack challenge. On the other hand, the challenge shouldn't be too difficult [7].

Strategies

Learning Requirements: In this case, performance requirements and evaluating criteria should be put in place to facilitate students estimate the probability of success in their learning [8].

Success Opportunities: This ambit promotes provision of challenge levels that allow significant achievement experience under both learning and performance conditions.

Personal Control: It advocates for provision of feedback and opportunities for control that maintain internal recognition for achievement [8].

3.4. Satisfaction Factor

These factors claim that situations where students' learning outcomes are consistent with their expectations and effort normally make them feel relatively good about those outcomes. Such students will remain motivated [7].

Strategies

Natural consequences: It encourages provision for opportunities to employ recently attained knowledge or skill in a real or stimulated environment [8].

Positive consequences: Provide feedback and reinforcements that will sustain the desired behaviour [8].

Equity: it refers to maintaining consistent principles and penalties for task achievement [8].

3.5. Social influence Factor

Social influence refers to the extent to which the individual perceives that important others believe he or she should use new technology. Theory of Reasoned Action (RA) pioneered in researching subjective norm which was later transformed into social influence in UTAUT [18]. Social influence has been widely used in previous studies [5]; [18]; [20]. Most previous studies applied social influence to predict adoption of new technology [20]; [16]. In this study social influence will be employed to predict motivation to use mobile learning technologies by tertiary students. In spite of social influence importance in predicting students' motivation to use mobile learning systems, it has been found to be of limited importance for those with significant mobile learning experience. Therefore, other people's influence weigh heavily in motivating students to use before one has acquired sufficient experience to feel confident about making an independent decision [20]; [16].

3.6. Facilitating Conditions factor

Facilitating conditions refer to students' perceptions of the resources and support available to perform a behavior [2]; [17]. UTAUT asserts that performance expectancy, effort expectancy, and social influence are direct predictors for behavioral intention to use a technology, while behavioral intention and facilitating conditions determine technology use. However, in this study the researcher argues that facilitating condition does not only influence mobile learning adoption but it also motivates students to learn using mobile technologies.

4. Hypothesized Model

Figure 1 shows the hypothesized model for mobile learning motivational elements. Hypotheses have been established based on this hypothesized model.

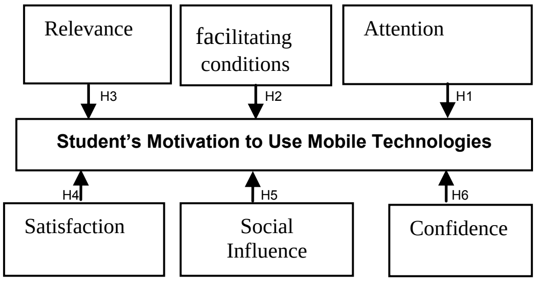

Figure 1: Mobile learning motivational hypothesized model

H1: Attention has positive effect on a student's motivation to use mobile technologies.
H2: Facilitating conditions have positive effect on a student's motivation to use mobile technologies.
H3: Relevance has positive effect on a student's motivation to use mobile technologies.
H4: Satisfaction has positive effect on a student's motivation to use mobile technologies.
H5: Social influence has positive effect on a student's motivation to use mobile technologies.
H6: Confidence has positive effect on a student's motivation to use mobile technologies.

5. Hypothesized Model Methodology

This study adopted an explanatory case study approach. The purpose of such a case study is both theory building and testing since casing involves a detailed description of a complex entity or process with a view to inform [pedagogical] policy development [4]. Consequently, the study's intention was to draw on an existing model to understand its explanatory power, further broaden its constitutive variables and apply them to real world contexts. Such a contribution to theory or (model building) and confirmation (testing) is critical to generating theoretical insights closely grounded in real experiences [4] in contrast to speculative armchair theorising [15]. To explore factors that influence mobile learners' motivation to learn using WhatsApp instant messaging, the researchers adopted WhatsApp mobile instant messaging as a collaborative environment which enabled lecturer- student and students-peer interaction outside the classroom.

6. Research procedure

The researchers requested all students with Web-enabled devices (Smart phones, PDAs, iPhones, IPads and tablets) to download WhatsApp to their devices and he randomly grouped students into virtual discussion forums comprising at most 10 participants per cluster inclusive of the lecturer. The lecturer designed a manual on how to download, install and use WhatsApp. The manual was placed onto the institutionally sanctioned learner management system for easy accessibility to students. The student clusters discussed questions generated in their respective clusters including one question the lecturer posed daily to all clusters. Students directed tough questions they failed to address to the lecturer online or reserved them for lectures where the lecturer would give detailed explanations and feedback to the entire class. The lecturer informed students about his occasional availability on WhatsApp at any time (between 8 am-10 pm) to address their academic queries, problems and issues. To address perceived knowledge differentials between peers, students were required to log on WhatsApp using their cell numbers (call ID) to ensure their anonymity during intra-cluster interactions. The lecturer, however, used his authentic identity for easy recognition by all students.

7. Data Analysis

The study employed quantitative analysis approach. This study utilised Partial Least Squares (PLS) and SPSS for data analysis). PLS was employed for modeling associations among sets of observed variables through latent variables. SPSS was exploited for statistical analysis including descriptive statistics, variance, and Cronbach's alpha [9]; [12]. Factor analysis and reliability testing were performed to ensure that all research constructs are reliable. Correlation analysis was performed to examine the relationship between model variables. Regression analysis was conducted to test the relationship between the whole set of predictors and dependent variables.

7.1. Demographic Profile of the Respondents

The descriptive of the demographic profile of the participants is shown in the table below. Data was collected from 217 participants. The majority of participants where female (57%), while male participants constituted 43% of the study population. These findings are consistent with [13], they reported more female participants in their mobile learning study compared to males.Black Africans (81%) formed the largest participants' race, while whites composed 9% of the study population. Coloreds and Asians were the minority with the following 6% and 2% respectively.

The majority of participants' age ranged from 20-25 years (81%). Participants within the 26-30 years age group constituted 11%, while participants above 30 years represented 8% of the study population. About 76% of the participants had no previous mobile learning experience while only 24% had used mobile learning before. Table 1 provides a summary of the participants' demographic profile.

Table 1: Demographic Profile Table 1.

Variable		**Frequency**	**Percentage (%)**
Gender	Female	127	57
	Male	93	43
Race	Black African	180	83
	White	20	9
	Colored	13	6
	Asian	4	2
Age	20-25 years	176	81
	26-30 years	24	11
	>30 years	17	8
Mobile learning Experience	Experienced	165	76
	No Experience	52	24

7.2. Factor Analysis and Reliability Testing

Research constructs' reliability was established using factor analysis and reliability testing were performed to ensure that all research constructs are reliable. The complexity of research constructs was diminished by performing factor analysis. Furthermore, factor analysis was executed to guarantee that minimal latent constructs were used to explain the shared variance of measured constructs use in the questionnaire [6]. Consistency of the survey data was maintained by applying Cronbach's alpha [19]. Cronbach's alpha is based on average correlation of items within the test because it will be interpreted as coefficient [3]. [11] argues that items whose Cronbach's alpha is at least 0.7 are significantly reliable. The results for these tests are shown in the table below.

Seven variables were considered in this study namely: Attention, Relevance, Confidence, Satisfaction, facilitating conditions, Social Influence, and Motivation to use mobile learning. Factors loadings were calculated for variables individual items and they ranged from 0.619 to 0.866, Cronbach's alpha was calculated for each variable, and each was found reliable (A = 0.781, R=0.792, C=0.863, S=0.836, FC=0,701, SI=0.713, MTU=0.772). Table 2 displays the statistical representation for Cronbach's alpha, Factor Loading, percentage variance and cumulative variance.

Table 2: Statistical presentation

Variable	Item	Cronbach's Alpha	Factor Loading	Percentage Variance	Cumulative % of Variance
Attention (A)	A1	0.721	0.736	12.211	12.211
	A2		0.789		
	A3		0.811		
Relevance (R)	R1	0.792	0.691	10.234	22.445
	R2		0.723		
	R2		0.662		
Confidence (C)	C1	0.763	0.834	17.413	39.858
	C2		0.812		
	C3		0.861		
Satisfaction (S)	S1	0.836	0.866	22.201	62.059
	S2		0.831		
	S3		0.822		
Facilitating Conditions (FC)	FC1	0.631	0.619	5.369	67.428
	FC2		0.761		
Social Influence (SI)	SI1	0.713	0.763	6.123	73.551
	SI2		0.721		
	SI3		0.652		
Motivation To Use (MTU)	MTU1	0.772	0.762	10.100	83.651
	MTU2		0.744		

Table 3: Square root of AVEs and Correlations

Variables	A	R	C	S	FC	SI	MTU
A	**0.76**						
R	0.53	**0.81**					
C	0.61	0.66	**0.84**				
S	0.64	0.56	0.63	**0.81**			
FC	0.63	0.59	0.71	0.64	**0.77**		
SI	0.58	0.63	0.59	0.61	0.62	**0.75**	
MTU	0.62	0.62	0.62	0.58	0.61	0.67	**0.84**

Bold numbers in diagonal lines are square root of AVE of each variable
Numbers in non-diagonal lines are correlation coefficient between the each variable and the other variables.

7.3. Correlation Analysis

Correlation analysis was performed to examine the relationship between attention, relevance, confidence, satisfaction, facilitating conditions, social influence and motivation to use mobile learning. The results support the existence of multi-colinearity as all correlation values are above 0.7.

Table 3: Hypothesis Testing

Hypothesis	Path	ß	significant	Result
H1	A ⟶ MTU	0.231	0.033	Accept
H2	FC ⟶ MTU	0.021	0.651	Reject
H3	R ⟶ MTU	0.312	0.019	Accept
H4	S ⟶ MTU	0.421	0.013	Accept
H5	SI ⟶ MTU	0.121	0.021	Accept
H6	C ⟶ MTU	0.224	0.032	Accept

8. Hypothesis Testing and Discussion

H1: Attention has positive effect on a student's motivation to use mobile technologies.
From Table: 3, the significant value for attention is 0.33 which is less than 0.05 at 95% significant level. Consequently, the Hypothesis 1 is supported with β value 0.231.This suggests that the mobile instructions that capture and sustain students' attention are essential in predicting mobile learners' motivation to use mobile technologies for learning. Specifically, this study further argues that students are motivated to learn using mobile technologies if these systems capture and sustain their attention to learn. These findings corroborate [8]'s views that motivation is driven by instructional designs that capture and sustain students' attention.

H2: Facilitating conditions have positive effect on a student's motivation to use mobile technologies.
From Table: 3, the significant value for facilitating condition is 0.651 which is greater than 0.05 at 95% significant level. Accordingly, the Hypothesis 2 is not supported with β value 0.021. These findings revile that facilitating conditions could not motivate students to learn using mobile technologies. Probably this was caused by the fact that students were not provided with any resources and support in this study since they used their mobile devices.

H3: Relevance has positive effect on a student's motivation to use mobile technologies.
From Table: 3, the significant value for relevance is 0.019 which is less 0.05 at 95% significant level. Therefore, the Hypothesis 3 is supported with β value 0.312. This suggests that learning using mobile technologies was perceived to be helpful in accomplishing students' goals, resulting in motivating students to learn.

H4: Satisfaction has positive effect on a student's motivation to use mobile technologies.
From Table: 3, the significant value for relevance is 0.013 which is less 0.05 at 95% significant level. Therefore, the Hypothesis 4 is supported with β value 0.421. This is an indication that mobile learning enables learners' effort to achieve outcomes that are consistent with their expectations leading to motivating mobile learners.

H5: Social influence has positive effect on a student's motivation to use mobile technologies.
From Table: 3, the significant value for relevance is 0.021 which is less 0.05 at 95% significant level. For that reason, the Hypothesis 4 is supported with β value 0.121. Most social influence in this study came from lecturer and peers resulting in motivating mobile learners to learn.

H6: Confidence has positive effect on a student's motivation to use mobile technologies.
From Table: 3, the significant value for confidence is 0.032 which is less 0.05 at 95% significant level. For that reason, the Hypothesis 4 is supported with β value 0.224. This suggests that mobile technologies create a feeling of success among the students thereby boosting their confidence which eventually motivates them to learn using mobile technologies.

9. Conclusion

The current study confirmed that ARCS model is effective in establishing motivational factors that influence mobile learners to learn. However, the ARCS model's highest potential in mobile learning WhatsApp application may be realized through blending traditional lecturing and mobile learning. Furthermore, social influence was also found to influence motivation of mobile learners. However, facilitating conditions were proved to be insignificant in motivating mobile learners. The study extended ARCS model by adding social influence as another construct that contributes in mobile learner motivation. Overall, the study establishes factors that influence motivation of mobile learners hence contributing to the mobile learning board of knowledge.

The study furthermore confirmed that WhatsApp mobile learning initiative is capable for motivating students. Attention, relevance, satisfaction, social influence and confidence are the factors that influence motivation to learn for the tertiary students. Facilitating conditions were found to be irrelevant for motivating mobile learners in the WhatsApp mobile learning context.

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Presenter: This paper is presented by Aaron Bere

Developing Educational Game Software Which Measures Attention and Meditation with Brainwaves: Matching Mind Math

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Abstract

An educational game is computer software that enables students to learn course topics or to develop their problem-solving skills by taking advantage of their desire and enthusiasm to play. Today, educational software and educational games software are increasing rapidly and their development has improved. Brainwaves produce weak electrical signals that can be measured from the skull. Electroencephalography is a system that measures the activity of brainwaves using an electrical method. The Brain Computer Interface is a system that converts electrophysiological actions or metabolic rate to signals to be interpreted by a device. This study aims to develop an educational game that measures attention and meditation rates using the EEG Device. In this study, an educational application named "Matching Mind Math" is developed using Flash software. The application will appeal to elementary school students and fundamental mathematical problems will be provided to students. In order to measure the attention and meditation values of students they will wear a electroencephalograph device provided by "Matching Mind Math". NeuroSky MindwaveMobile will be used as an electroencephalography device. The attention, meditation and correct answers are seen with Matching Mind Math when students play the game.

Keywords: *Education, Game, EEG, Brain Computer Interaction, Attention, Meditation*

1. Introduction

The game world is now very advanced and new methods are also being investigated from different sources such as using the mouse, keyboard, joystick, which are mainly used for input device by game developers. Gaming technology is unstoppable as a result of the enormous numbers of gamers who introduce new technologies in games [1].

Because there are cost-effective electroencephalography (EEG) devices that can be developed for anyone, Brain Computer Interface (BCI) is more important than ever for the game industry. For example, game developers can move a character with brainwaves or they can use the mouse, keyboard, joystick and EEG devices together and gaming can be more entertaining.

Educational games are designed to teach fundamentals about a certain topic or to provide consolidation and repeat previously learned knowledge in a more comfortable environment. Brainwaves have a great importance for educational games. Teachers and parents can see the attention and motivation rates of the student when a student plays educational games using an EEG device. Thus, they can understand where and when the student's attention is decreasing or increasing and the appropriate time for student's learning.

Given all the developments in the world of gaming, there is a great lack of educational game software with integrated BCI. In the scope of this study, an educational game named Matching Mind Math has been developed with Flash software and students' attention and meditation rates can be seen with an EEG device.

2. Overview of the Literature

2.1. Educational Games and Educational Game Design

Educational learning games enable students to reach the objectives of their learning topics and gain educational experiences. General elements in educational games are unity, exploration, competition and challenge, because challenge and competition motivate students and make them learn [2].

Although computer games are activities that include rules, objectives, feedbacks, interaction and results, they also offer learning potential to students due to their natural characteristics [3]. The studies done on 236 students in Malaysia revealed that the average amount of time spent playing computer games was 8.47 hours per week and the average playing game frequency among students was 75.8%. (91.3% of male students, 54.1% of female students) [4]**.** With this result, the utilization of educational games for learning can be deduced from their perception as popular activities for children. Educational game design is difficult but designing an educational system is more difficult [5]. Although the focus of the game is teaching, the teachers and students provide real contributions to the game in the designing game process, by sharing their ideas about the game's scenario and game's entertainment [6].

Some factors are important for educational game design; to understand the gamers according to age, gender and experience of previous games; preparing appropriate content for the game; appropriate methods and techniques of learning must be determined; Appropriate sound effects, graphics, user control, feedback should be determined as the game elements [7]. Educational game design principles need to be taken into consideration for a game's success.

2.2. EEG Signals

As a result of the electrical activity of the cells, the body of organism consists of many electrical signals, and one of the electrical signals is electroencephalogram (EEG) which is the measurement of electrical activity that occurs in the brain [8]. The EEG was developed in 1929 by the German psychiatrist Hans Berger.
Without complex techniques, brainwaves can be measured and analysed by using a non-invasive EEG with a dry electrode on the forehead [9]. Today, affordable EEG devices are available for users.
The EEG spectrum has separate bands with special names based on their dominant frequency contain waves as follows [10]:

- Delta (δ) waves: Frequencies are: 0.5–4 Hz, amplitudes are: 20–400 μV. They are encountered in deep sleep, very low activity in the brain, such as general anaesthesia.
- Theta (θ) waves: Frequencies are: 4–8 Hz, amplitudes are: 5–100 μV. It is encountered in dreaming sleep, medium depth of anaesthesia, low activity in brain such as stress in normal individuals.
- Alfa (α) waves: Frequencies are: 8–13 Hz, amplitudes are: 2–10μV. They are encountered when awake individuals have a complete physical and mental rest in a place where there is no external warnings, eyes are closed. They are seen in healthy individuals in comfortable cases. The meditation value in our application occurs with these waves.
- Beta (β) waves: Frequencies are: higher than d13 Hz, amplitudes are: 1–5 μV. They are encountered in focused attention, mental work, sensory information processing. Beta waves correspond with the highest level activity of the brain. The attention value in our application occurs with these waves.

It is observed that when the wave frequency increases, amplitudes decrease.

2.3. Brain Computer Interface (BCI)

Technological advances for the measurement of brain activity, stimulation of nerve tissue, advances in computer technology and the science of robotics allow creating interfaces between human brain and artificial devices, these interfaces are called the Brain Computer Interface (BCI) [8]. BCI is a type of communication system that outputs and commands not to transmit out to the world with normal ways but that system recognize and analyse brain activity [11] .

The mode of operation of the BCI is shown in Figure 1.

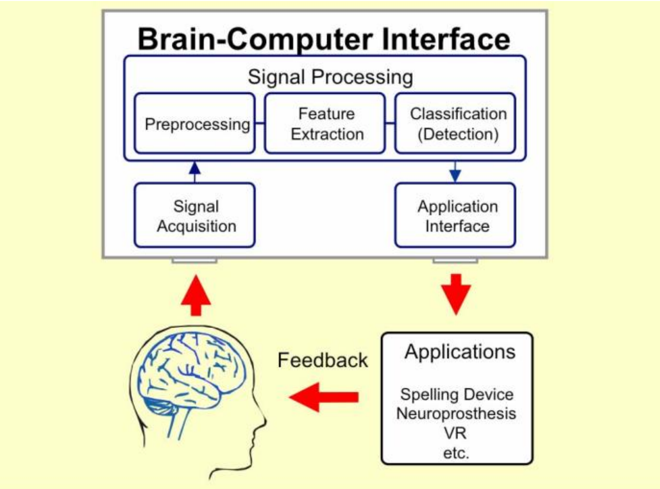

Figure 1. Brain Computer Interface [12]

The basic components of BCI systems can be listed as follows [11];

- Signal acquisition
- Signal processing: feature extraction
- Signal processing: conversion algorithm
- Output device
- Management protocol

Previous years' BCI applications were made for patient users but nowadays BCI applications have been developed for healthy people [13] such as for games, meditational applications, educational applications etc. Therefore, many BCI applications are now available and more developers are working on BCI applications.

2.3.1. Importance of Brainwaves in Education

Training is done without taking consideration of students' meditation, stress and attention levels in schools. That problem concerns every student. These questions are important; How do I pay attention, listen, concentrate and remember; much less relax [14]?

Yoshitsugu Yashi [9] conducted a study on real life brainwave measurement. The study was conducted on a 22-year-old male student. The measurements were performed on a normal college day. In the morning class, the student concentrated and at lunch time the student was relaxed. The student was sleepy at the beginning of the afternoon class, then the student concentrated in the later class. After school, the student was relaxed again. The student's readiness for learning can be understood by measuring brainwaves.

Teachers can empirically determine whether the student is paying attention with brainwave measurement [15]. Educators and parents estimate a student's achievement with correct answers and attention rates.

There is a strong correlation between correct answers and attention waves [15]. Thus, brainwaves have an importance for education.

2.3.2. Importance of Brainwaves in Games

When BCI is thought of in terms of game play, it seems to use three methods the game industry. Playing games is possible with brainwaves without using joystick, keyboard or mouse devices, which are well-known game input devices, and game manufacturers produce games which are played with brainwaves by EEG devices. Alternatively, game developers can measure some states of games such as boredom and excitement by using brainwaves for evaluating the efficiency of games. Since 2004, EmSense has been using biofeedback to help game designers evaluated new products [16]. Finally, users can view their meditation and attention levels when playing a digital game.

Some constraints are faced when using brainwaves as an input device. Because the technology is still limiting and only concentration and meditation is not enough for games, some players think that they don't have total control like playing with a joystick [17]. Thus, the game's entertainment may be reduced. That can be a disadvantage for using brainwaves in games.

3. Aim of the Study

The aim of this study is to develop an educational game that measures attention and meditation values that are important for learning by brainwaves when students play the game. An educational game software named Matching Mind Math (MMM) has been developed for the scope of the study. The student matches the maths operations with correct answers while measuring brainwaves with MMM. NeuroSky MindWave Mobile is used as an EEG device to measure brainwaves and MMM developed by Adobe Flash Software. The attention and meditation output ranges from 1 to 100, and higher values indicates more attention. In MMM, the student races with time and aim to give more attention and meditation.

Today, many varieties of educational games and many games, and applications with integrated BCI are available. BCI applications are also important in many other fields such as education as mentioned in the literature. The relationship between attention, meditation and number of correct answers can be understood by educational games with integrated BCI. High meditation and attention is important for learning. When a person becomes upset, cortisol levels are elevated in the part of brain in which learning and memory reside, which can have a negative effect on learning [18]. The study will be an example for developing educational games that use EEG devices.

4. MMM Development

In this section, the MMM game's development stages will be handled.

4.1. Software and Hardware Devices Used in MMM

In this application, Flash is used as the software and NeuroSky MindWave Mobile is used as the EEG device.

4.1.1. Flash Software

Adobe Flash CS 5.5 software has been used for developing games and the programming language used is ActionScript 3.0. The educational game engine that is centre of designing various games is needed to increase the student's learning interest is important for education and it can be said that Action Script design is the core of the game engine [19]. Reasons for using Flash Software are:

- Can use rich visual effects, which affect students
- Action Script language is a rich language.
- Preparing applications with Flash brings advantages in terms of cost and time

4.1.2. NeuroSky MindWave Mobile

NeuroSky MindWave mobile translates brainwaves into digital information and beams it wirelessly to computers or mobile devices [17]. Figure 2 shows MindWave Mobile. About 1,700 software developers are working with NeuroSky's technology and they make mind-controlled computer games for their works or NeuroSky [17].

We use NeuroSky MindWave Mobile for our application. MindWave Mobile uses the TGAM1 module, and has automatic wireless pairing, takes a single AAA battery, Bluetooth v2.1 Class 2 (10-metre range), static headset ID (headsets have a unique ID for pairing purposes) [20]. MindWave Mobile measures raw-brainwaves, processing and output of EEG power spectrums (Alpha, Beta, etc.). Processing and output of NeuroSky proprietary eSense meter for attention, meditation, and other future meters, EEG/ECG signal quality analysis (can be used to detect poor contact and whether the device is off the head) [20].

Figure 2. NeuroSky MindWave Mobile [20]

4.2. Progress Of MMM

At first, the student wears the EEG device and connects the device with the computer to play the game. Attention, meditation and poor signal levels can be seen on the first screen of MMM. When the student presses the start button, the timer and average attention and meditation levels are reset, than the average attention and meditation rates start to be calculated. The student matches mathematical operations with true answers using a drag and drop game. The finishing time and average attention and meditation rates are seen when the student presses the finish button. The green check marks are seen on the left side of the correct answers.

The flow chart of the progress of the game can be seen in Figure 3.

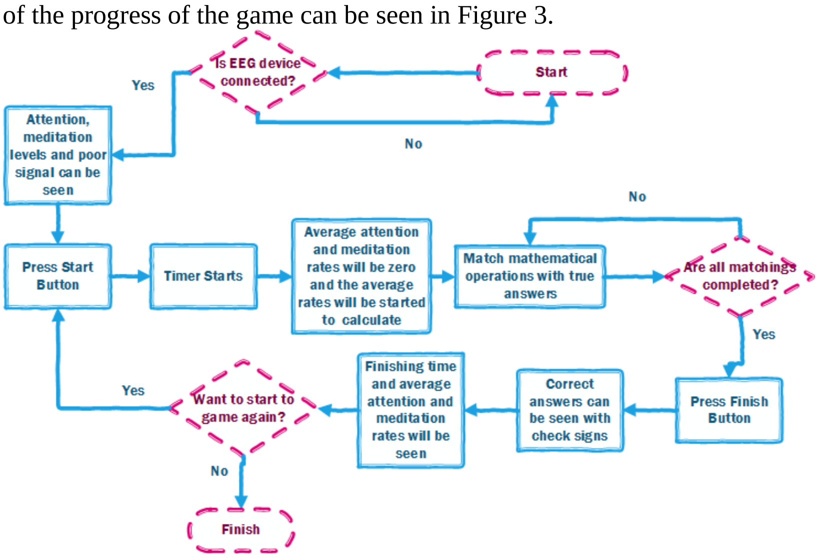

Figure 3. Flowchart of Progress of MMM

A screenshot from MMM is shown in Figure 4.

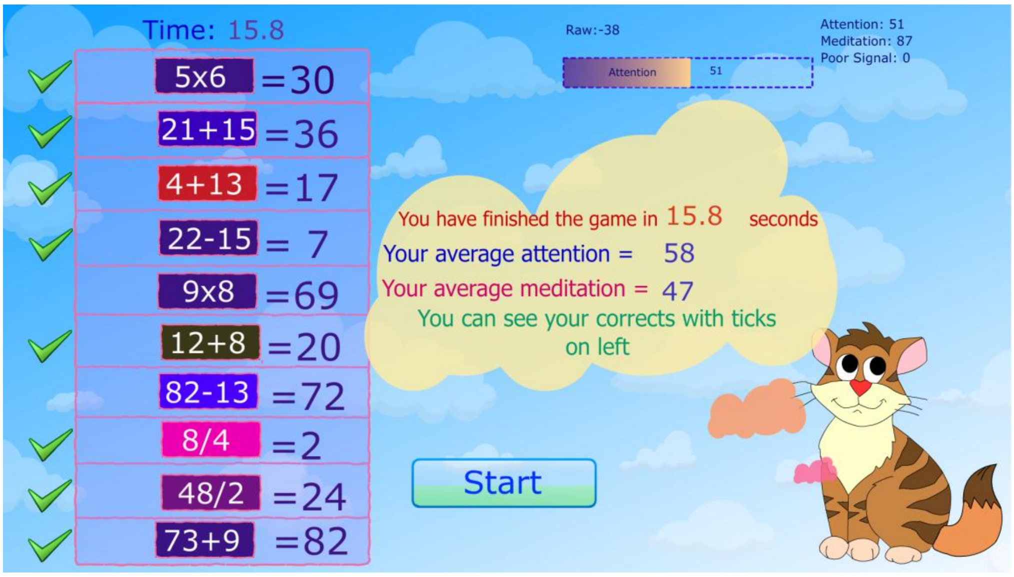

Figure 4. A screenshot from MMM

A student wearing an EEG device and playing MMM is shown in Figure 5**.**


Figure 5. A student wearing EEG device is playing MMM.

4.3. Programming

NeuroSky MindWave uses the Think Gear chipset, which is the core of brainwave sensing technology. Think Gear Socket Protocol (TGSP) is a JSON-based protocol, and it was designed to allow languages without a standard serial port API [21] . Therefore, the ThinkGear socket protocol is used in programming and we adapt it to Flash with API.

ActionScript 3.0 is used for the game's programming. At first the ThinkGear Socket Protocol was coded. The "Hello EEG" application in the NeuroSky developer's page is helpful for our study. Example code from ThinkGear Socket is as follows:

```
configuration["format"] = "Json";
thinkGearSocket = new Socket();
thinkGearSocket.connect("127.0.0.1", 13854);
thinkGearSocket.writeUTFBytes(JSON.encode(configuration));
thinkGearSocket.addEventListener(ProgressEvent.SOCKET_DATA, dataHandler);
```

In MMM, to match the operations with the correct answer, drag and drop codes have been used. For calculating the average attention, the following example of ActionScript code has been used;

```
addEventListener(Event.ENTER_FRAME, attention)
function attention(e:Event):void{
        attentionlevel= attentionlevel+ int(attentiontext.text);
        counter=counter+1
        averageattention=(attentionlevel/counter)}
```

Thus, the average attention level will be calculated.

5. Conclusion and Suggestions

This study only examines an educational game's developing steps that measure attention and meditation rates by the EEG device and brainwaves. Considering the importance of the brainwaves, attention and meditation for education as discussed in the literature, MMM has developed for an example game. The developed MMM game is not tested on students and MMM's effects are not investigated.

Meditation is important because it is known that stress affects learning. Students, parents or teachers can see the average attention and meditation level in MMM. Only a high level of attention may not be sufficient for learning. If attention and meditation levels are high, the student is found to be in an appropriate state for learning. If necessary, students can be provided with a stress-free environment in which to learn.

In the literature, there are inadequate educational games that can be controlled by brainwaves or that measure attention and meditation rates. Developing those types of games is suggested due to handled reasons. Improving and testing MMM with students and obtain and interpret the test results are suggested. This could be the subject for a future study. In this way, the benefits of MMMs can be discussed from every aspect.

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Writing Online Journal Reflections in an Engineering Course Encourages Critical Thinking

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Abstract

Reflective writing helps improve critical thinking skills, such as questioning and reasoning, recognizing assumptions, presenting and evaluating data, and drawing conclusions: all important for engineering students. Thus, to encourage engineering students to reflect on material taught in a technical course, fifteen journal prompts were developed based on Bloom's Taxonomy. Once or twice a week, the prompts were delivered to students through an online classroom management system. When students understood that a contemplative response to the prompts would increase understanding and technical competency, nearly 90% completed the assignments. A coding method was developed to analyze the written responses, to determine which critical thinking skills the students were applying. The initial analysis shows that the students who understood the purpose of the journal responses applied all four types of critical thinking skills as they wrote. Results from the current approach will be presented at the conference, and a discussion for a more in-depth analysis will be initiated.

Keywords: *Critical thinking, Online journal, Engineering writing.*

1. Critical Thinking in Learning

A college education is expected to improve students' critical thinking skills to help them develop a deep approach to learning. Ideally, this occurs in every course, including engineering courses. While critical thinking is not listed explicitly as an ABET outcome (note that engineering programs in over 20 countries are accredited by ABET), it is evident within several, such as (a) an ability to apply knowledge of mathematics, science and engineering; (b) an ability to design and conduct experiments, as well as to analyze and interpret data; (e) an ability to identify, formulate, and solve engineering problems; and (i) a recognition of the need for, and an ability to engage in life-long learning [1].

Many definitions of critical thinking have been published, and most include an emphasis upon questioning and reasoning, recognizing assumptions, presenting and evaluating data, and drawing conclusions ([2] – [5], for example). Thinking critically is a process, which requires students to relate new ideas to previous experiences or knowledge [6]. To begin the process, a student must first possess some information about the subject. Then the student must also have the ability to reflect on and question the new knowledge he or she is acquiring, and see how it fits with what is already known. This "reflective" component of critical thinking is somewhat parasitic upon the "knowledge" component [7]. That is, a student's ability to "think critically" can vary with the amount of knowledge he or she possesses, as well as his or her capacity to contemplate the new information. Third year engineering students should have enough foundational knowledge to think critically about new material. What they may not yet possess, or put into practice, is the reflective component. This is especially important as part of the ABET criteria of lifelong learning [10, 11].

Much research has investigated how best to improve students' critical thinking skills. Writing is a primary method. As a student writes about a subject, it can become more clear [8] and lead to a more complete and detailed understanding [9]. The more a student writes, the more he or she develops and uses critical thinking skills – especially if the writing assignment is properly designed and encourages reflection, which can trigger critical thinking [10, 12].

Writing occurs in laboratory courses for most engineering students so the ABET criteria of communication skills and lifelong learning can be accomplished and assessed. At one institution, redesigning an engineering laboratory course using Bloom's Taxonomy (see Figure 1) as a framework improved students' critical thinking skills. By the end of their course, the students were functioning at the higher Bloom's levels (analyzing, evaluating and creating) as they revised and clarified their "mental modes of chemical engineering" - i.e., their critical thinking skills [13]. While this type of writing is important, there are additional places where writing – and critical thinking skills – can be improved in engineering courses.

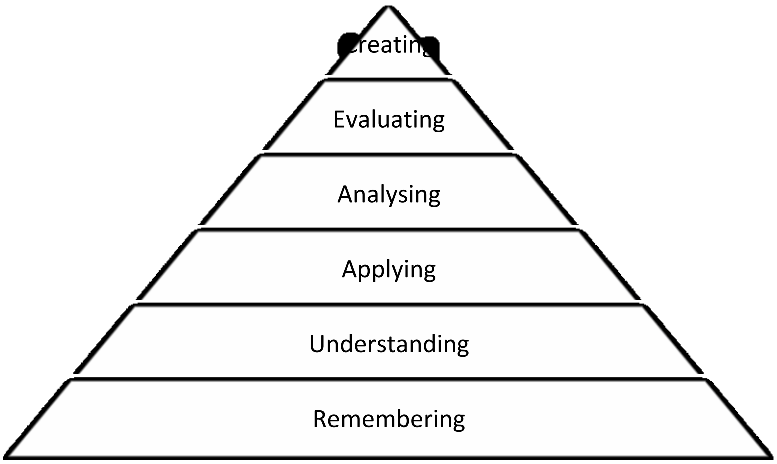


Figure 1 Bloom's Taxonomy updated with the new verbage [14].

In this study, a series of online journal prompts were developed to improve students' critical thinking skills in a typical third year applied chemical engineering course. The journal prompts were written at different levels of Bloom's taxonomy and the responses were analyzed for four areas of critical thinking: 1. Questioning and reasoning; 2. Recognizing assumptions; 3. Presenting and evaluating data; and 4. Drawing conclusions. Initial results indicate that the students did apply elements of critical thinking as they responded to the prompts, which should increase their technical competency. Improving students' critical thinking skills by having them write, in addition to homework and exams, is a novel approach for an applied engineering course.

2. Methodology

Applied Fluid Flow and Heat Transfer is a junior level chemical engineering course that enrolls 20 – 25 students each spring. In this course students explore the theory and application of fluid dynamics and heat transfer from the chemical engineer's point of view. They are introduced to the design of equipment such as pumps, agitators and heat exchangers that are used in chemical processes. After completing this course, students should be able to formulate and solve a variety of chemical engineering problems involving momentum and heat transfer.

Each week, the students meet twice for a 50-minute lecture class and once for a two-hour problem solving session. Before the 50-minute portion, students complete a worksheet outline of the chapter reading. During this class, students review and ask questions about the assigned reading, watch short videos demonstrating the concepts for the day, and describe solution methods for example problems. Occasionally, the professor presents a short lecture. After most meetings, a journal prompt is placed on the classroom management system and the students respond in 100 words or less. During the two-hour class session, the students solve more involved problems, often in small groups. The course grade is based on homework, exams, projects and the journal responses.

The journal responses were piloted during the Spring 2012 semester when this professor taught the course for the first time in several years. The Institutional Review Board reviewed and approved the research proposal and informed consent letter that the students signed.

In Spring 2012, students were asked to respond to a short answer question once a week. After analyzing the data from the pilot questions, fifteen new journal prompts were written during the summer in preparation for the Spring 2013 semester. These new prompts were designed to cover the levels of Bloom's Taxonomy, as shown in Table 1.

Table 1. List of prompts used during the Spring 2013 semester.

Date	**Prompt**	**Bloom's Level**
January 28	Underlying the unit operations of chemical engineering are some basic concepts. Think about the ChE courses you have taken so far. List some concepts and how you think they will link to unit operations.	Analyzing
February 1	Consider a manometer and describe how the pressure difference ($p_A - p_B$) would change if we 1. Replace fluid A with a denser fluid 2. Replace fluid B with a denser fluid 3. Increased the diameter of the manometer 4. Increased the horizontal distance between points *a* and *b* 5. Increased the distance R_m	Understanding
February 4	My parents used to have a small fountain next to the patio, with the water continuously circulated by a small pump. The water fell through three pools to the bottom, then was recirculated to the top, where it flowed from an antique water pump (from my grandparents' Kansas homestead). If you were going to apply the Bernoulli equation to this problem, which terms would you include? Where would you locate positions (*a*) and (*b*)?	Applying
February 8	What is an application of thin fluid flow on a solid that you might have seen at home or on campus? How thick do you think the layer was?	Remembering; Applying
February 11	Think about a turbulent flow example you have seen recently. Briefly describe it, and determine if skin friction, form friction, or both were present.	Analyzing
February 15	Where is a piping network on campus?	Understanding
February 25	The supply closet has a vacuum pump that provides a vacuum line to the lab in AEC 214. If you needed to analyze the flow in that line, would you consider it adiabatic friction flow? Why?	Analyzing
March 4	A drip coffee maker could be thought of as a packed bed: water drips through the coffee grounds and through the filter to the coffee pot. What would you estimate the superficial velocity to be? the average velocity through the grounds? the void fraction? [Order of magnitude estimates]	Analyzing
March 8	The air flowing out of a hair dryer has a velocity of about 15 m/s. A ping pong ball can be suspended by a hair dryer, so we could assume the minimum fluidization velocity for a bed of ping pong balls would be somewhere around 15 m/s. What are some reasons this is so much higher than the minimum fluidization velocity for the flue gas problem?	Analyzing
March 11	Why is inter-stage cooling important for a multi-stage compressor?	Understanding
March 15	Do the orifice and Venturi meter in the fluid flow experiment meet the requirements for the coefficients the book suggests?	Applying
April 2	What was most memorable about the visit to the steam plant?	Remembering
April 5	Today we discussed three methods to analyze an unsteady-state conduction problem. What is another example of an unsteady-state conduction problem, and which method would you use to analyze it?	Analyzing
April 22	Describe a condensation example (find one on YouTube if you need to). Was it film or dropwise? What value would you assume for a Reynolds number? Why?	Analyzing
April 29	Suppose I gave you a solid copper tube and a copper heat pipe to hold. Which would feel cooler? Why?	Analyzing

The prompts were placed as an "Assignment/Online Text" option in the classroom management system, Moodle. This allowed the students to directly type their responses into a small box. They can be graded online, and the professor can comment on student responses, correcting a concept if necessary. After all responses to a prompt have been entered, they can be downloaded as a zipped file, then unzipped and opened in a word processing file for analysis. The resulting document has no student names attached, so the analysis is anonymous.

Unfortunately, due to time constraints in Spring 2013, most student responses were not read until the end of the semester, and the two-way conversation with the professor did not occur. A few students wrote erroneous responses, which have been noted in the analysis, but it was too late to respond to the students. Other students asked a question in the midst of their response; again, it was too late for the professor to respond to their question.

For the initial evaluation to determine if critical thinking was being triggered, the number of words in each response was counted. Next, each response was carefully read and phrases and sentences were divided into responses of the four areas of critical thinking that were being investigated (Questioning and reasoning; Recognizing assumptions; Presenting and evaluating data; Drawing conclusions) and the percentage of words in each area was calculated. Figure 2 shows a portion of one response with the analysis shown.

February 11: Think about a turbulent flow example you have seen recently. Briefly describe it, and determine if skin friction, form friction, or both were present.

Person 5:

I was watching the Daytona 500 qualifying today and thought about the turbulent flow that occurs around the cars. The cars are meant to be aerodynamic and reduce friction as much as possible. *Because of their design and shape, form friction is somewhat limited*. *Skin friction causes the bulk of the friction*.

52 words

Questioning and Reasoning = 14 words

Recognizing Assumptions = 0 words

Presenting and Evaluating Data = 11 words

Drawing Conclusions = 8 words

Person 9:

Recently I had blood drawn, which made me think about blood flow which is an example of turbulent flow. *The plasma, platelets, white blood cell, and red blood cells are completely mixed up and not in clearly linear layers. The flow of blood is not slow as you can hear it rushing when using a stethoscope.* It is because of this that blood is flows turbulent. In a blood flow, unless an obstruction is present, there is very little to creating wakes and thus form friction is minimal. Skin friction, however, is in abundance due to the unseparated layers created by the high velocity.

104 words

Questioning and Reasoning = 14 words

Recognizing Assumptions = 38 words

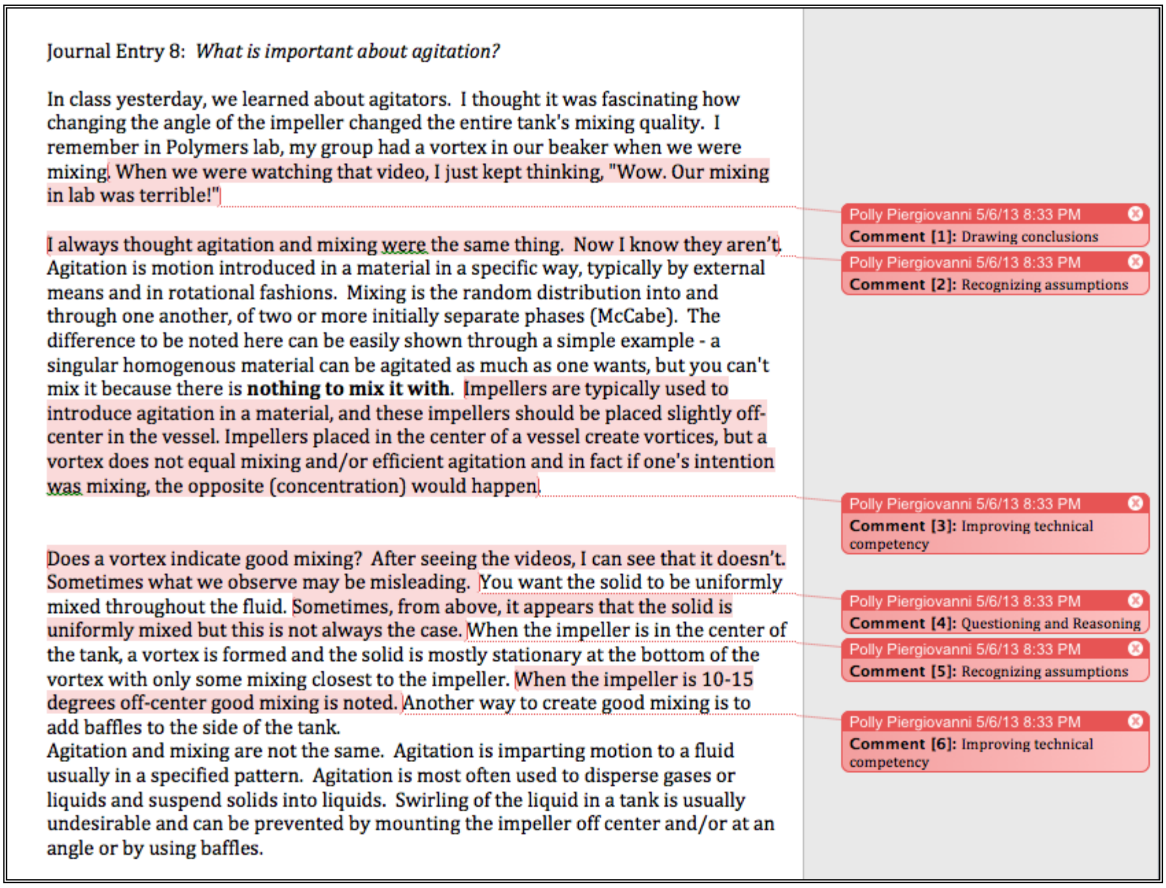
Presenting and Evaluating Data = 37 words

Drawing Conclusions = 10 words

Figure 2. Coding for two typical responses to the prompt given on February 11. The different fonts show the types of critical thinking indicated. The actual data was coded in four colors for more rapid analysis.

3. Results and Discussion

Figure 3 shows a typical response from the pilot test in Spring 2012. These students showed evidence of critical thinking (noted by the professor's comments in the margin), and even some deeper thinking when they linked what they learned in this class with experiences in another class. Similar results were obtained from some of the other prompts, but many responses were vague. It became clear that the students did not understand the purpose of the journal responses, or value what they might learn by contemplating the question before writing an answer. Many were just completing the exercise quickly in order to earn the 5% toward their grade.



Journal Entry 8: *What is important about agitation?*

In class yesterday, we learned about agitators. I thought it was fascinating how changing the angle of the impeller changed the entire tank's mixing quality. I remember in Polymers lab, my group had a vortex in our beaker when we were mixing. When we were watching that video, I just kept thinking, "Wow. Our mixing in lab was terrible!"

I always thought agitation and mixing were the same thing. Now I know they aren't. Agitation is motion introduced in a material in a specific way, typically by external means and in rotational fashions. Mixing is the random distribution into and through one another, of two or more initially separate phases (McCabe). The difference to be noted here can be easily shown through a simple example - a singular homogenous material can be agitated as much as one wants, but you can't mix it because there is **nothing to mix it with.** Impellers are typically used to introduce agitation in a material, and these impellers should be placed slightly off-center in the vessel. Impellers placed in the center of a vessel create vortices, but a vortex does not equal mixing and/or efficient agitation and in fact if one's intention was mixing, the opposite (concentration) would happen.

Does a vortex indicate good mixing? After seeing the videos, I can see that it doesn't. Sometimes what we observe may be misleading. You want the solid to be uniformly mixed throughout the fluid. Sometimes, from above, it appears that the solid is uniformly mixed but this is not always the case. When the impeller is in the center of the tank, a vortex is formed and the solid is mostly stationary at the bottom of the vortex with only some mixing closest to the impeller. When the impeller is 10-15 degrees off-center good mixing is noted. Another way to create good mixing is to add baffles to the side of the tank.

Agitation and mixing are not the same. Agitation is imparting motion to a fluid usually in a specified pattern. Agitation is most often used to disperse gases or liquids and suspend solids into liquids. Swirling of the liquid in a tank is usually undesirable and can be prevented by mounting the impeller off center and/or at an angle or by using baffles.

Polly Piergiovanni 5/6/13 8:33 PM
Comment [1]: Drawing conclusions

Polly Piergiovanni 5/6/13 8:33 PM
Comment [2]: Recognizing assumptions

Polly Piergiovanni 5/6/13 8:33 PM
Comment [3]: Improving technical competency

Polly Piergiovanni 5/6/13 8:33 PM
Comment [4]: Questioning and Reasoning

Polly Piergiovanni 5/6/13 8:33 PM
Comment [5]: Recognizing assumptions

Polly Piergiovanni 5/6/13 8:33 PM
Comment [6]: Improving technical competency

Figure 3. Example of a journal entry from Spring 2012 with four student responses. Areas of critical thinking are highlighted. The first entry shows a student's "aha!" moment – something they thought was true, they suddenly realized was not. Students signed an informed consent letter approved by the IRB.

The literature shows that the students are more likely to think critically about an assignment if they understand its purpose [10, 15]. Thus, on the first day of class in Spring 2013 the expectations of the journal responses were clarified, and students were presented with the results of research which shows that carefully thought-out responses to the prompts would increase their understanding and technical competency in the course (see Figure 4 for the handout provided). The students also completed an IRB-approved consent letter, giving permission to reproduce their work in a future research paper. Surprisingly, several students had questions about the journaling process and about critical thinking, resulting in a fruitful discussion on the first day of class. The initial analysis of the journal responses from this semester shows that most of the students did indeed think carefully about their responses, perhaps because they understood the value. Their responses showed more evidence of critical thinking.

<u>Journal Entries</u>

After most class meetings, a journal question will be posted on Moodle. Answering these questions is worth 5% of your grade. Thinking carefully about the question and answering it thoughtfully will help you learn the course material more deeply, as shown by research:

Dunlap, Joanna C., "Using Guided Reflecting Journaling Activities to Capture Students' Changing Perceptions" TechTrends, 20-26 (2006).

- Journal writing encourages reflection and supports acquisition of cognitive and metacognitive skills.
  - *Ask them and then define what cognitive and metacognitive mean*
- Journal writing encourages students to identify and analyze difficulties.
  - *If you can put into words what you are uncertain about, you might figure it out – and I will know what I need to explain more clearly.*

Wheeler, E. and McDonald, R.L., "Writing in Engineering Courses", J. Engineering Education, 481 – 486 (2000).

- Writing helps the writer to think critically and learn the subject more deeply.
  - *Again, putting equations and ideas into words cements it in your brain.*
- Writers are forced to think comprehensively and link thoughts in sequence.
- As students write, they experience and understand the material in a direct and personal way.
  - *Preparing a lecture – I really learn the material thoroughly. If you can explain a concept to someone else, you understand it better.*
- Writing improves technical proficiency.

As I read the journal responses, I will be looking for evidence of four types of thinking:

1. Questioning and reasoning
   - *Don't just believe it because the book or I say it – think about it and make sure it corresponds to what you already know.*
2. Recognizing assumptions
   - *What went into the equations we are talking about? In transport you made assumptions – find out where the unspoken ones are used here.*
3. Presenting and analyzing data
   - *Can you take a new situation – not from the text – and figure out how the text equations might apply?*
4. Drawing conclusions
   - *Put facts together and see what you can find, and apply to new or different situations.*

All leading to → Improved technical competency

- *The goal of the class – answering these journal questions will help you do better on the homework and exams in this class, and likely help you in lab as well.*

Figure 4. Handout provided to students on the first day of class to explain the journal assignment. Notes written in italics were spoken, not provided on the handout.

Fifteen new prompts were written for the Spring 2013 class, with careful attention to the Bloom's taxonomy level of thinking required for the response. The journals were assigned once or twice a week, and 89 – 100% of the students responded to each prompt. So far, four of the prompts have been coded (as was shown in Figure 2) to determine which types of critical thinking occurred. Each student's response was analyzed for the four areas of critical thinking and the percentage of words in each area calculated (see Table 2 for a sample of the data from the February 11 prompt). Next, for each prompt, the average word percentage was calculated for each area of critical thinking, as is shown in Table 3. The responses to the remaining prompts are currently being analyzed. It appears that prompts requiring lower levels of Bloom's Taxonomy result in mainly questioning and reasoning. Prompts at the higher levels appear to results in a broader distribution, although it is too early to draw firm conclusions. Alternative ways to analyze the journal responses are being considered. In any case, the students' responses showed they were reflecting, and critical thinking was "triggered".

Table 2. Data from sample students from the February 11 prompt. Student percentages do not sum to 100% because some words were used to describe the situation.

	Percentage of words that show:			
Student	**Questioning and Reasoning**	**Recognizing Assumptions**	**Presenting and Evaluating Data**	**Drawing Conclusions**
5	27	0	21	15
6	0	0	67	0
11	0	29	31	0
12	0	10	65	10
18	0	0	60	0

Table 3. Summary of critical thinking that occurred with the prompts analyzed so far.

		Average percentage of words that show			
Prompt	**Bloom's Taxonomy Level**	**Questioning and Reasoning**	**Recognizing Assumptions**	**Presenting and Evaluating Data**	**Drawing Conclusions**
Think about a turbulent flow example you have seen recently. Briefly describe it, and determine if skin friction, form friction, or both were present.	Analyzing	4%	9	41	8
Where is a piping network on campus?	Understanding	76	0	11	12
The supply closet has a vacuum pump that provides a vacuum line to the lab in AEC 214. If you needed to analyze the flow in that line, would you consider it adiabatic friction flow? Why?	Analyzing	0	91	0	9
The air flowing out of a hair dryer has a velocity of about 15 m/s. A ping pong ball can be suspended by a hair dryer, so we could assume the minimum fluidization velocity for a bed of ping pong balls would be somewhere around 15 m/s. What are some reasons this is so much higher than the minimum fluidization velocity for the flue gas problem?	Analyzing	7	9	61	14

Ideally, the next step would be to link student responses to performance. Unfortunately, detailed test data was not retained for the Spring 2013 class, but will be for Spring 2014. A few clues do indicate that student technical ability increased. For example, about 95% of the students responded to the February 11 prompt (determining types of friction present in a turbulent flow example). They first described the situation (about 40% of the words) and then presented and analyzed it to determine the types of friction present (about 40% of the words). One third of the students (7/18) drew some conclusions, one third (7/18) explained the assumptions behind their reasoning, and most students (16/18) presented and evaluated the situation: together, this indicates that critical thinking was occurring. However, two students wrote exactly backwards answers, switching the definitions of form and skin friction.

The first exam had three closed book short answer questions that required students to reflect on turbulent flow, including:

3. The pressure drop in a fitting for sudden expansion is higher than that for sudden contraction for the same ratio. Why?

The answer to this question required students to recognize and differentiate skin and form friction. Three students (16%) answered this incorrectly – including the two students who had written the backwards answers in the journal responses – but the rest of the class answered correctly. However, from the data gathered, it is difficult to determine if the journal question influenced student answers.

Qualitatively, the students with the most thoughtful journal responses were students who performed best on the exams, but they are also typically the best students overall.

4. Conclusions

Students wrote thoughtful responses to the journal prompts, especially after they understood how it could influence and enhance their understanding of the material. A method of coding the responses was developed and applied, although the method should be streamlined and improved. It is important to read, code and respond to student writing promptly, in order to correct misconceptions and answer questions. An initial analysis of the prompts shows that they did cause the students to think critically as they wrote their responses. In addition, it is important to keep records of test answers and scores to be able to link critical thinking to student performance.

5. Future Work

For the Spring 2014 course offering, five more prompts will be developed to include the "evaluating" level in Bloom's taxonomy. The method of coding will be improved to indicate the quality of critical thinking. Test questions will be written to correlate with the journal prompts, and records kept so some evidence of the effect can be noted. In addition, engineering colleagues who would be interested in assigning journal responses in their courses are being sought.

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Presenter: This paper is presented by Polly R. Piergiovanni

Problem Based Learning: a Different Approach for a Lower Dropout Rate

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Abstract

Recent statistics show a large number of unfilled jobs for graduates in the computing area, but a high dropout rate, even with the growing need for new professionals. Despite the extremely favorable moment for professionals due to the growth of the market in Brazil and the job offers it provided, a discouraging reality can be noticed: the labor shortage of the IT market. The exhaustion of the current school model through vocational training and the highly dynamic evolution of softwares, hardwares and all the technologies involved in product development makes necessary a new proposal to keep the students in the courses. Therefore, since this article is an introduction to a doctorate thesis proposal, we present a bibliographic review of the use of Problem Based Learning (PBL) methodology in colleges to make those classes with high reprobation and dropout rates more appealing to students, in order to increase their productivity and lower these rates.

Keywords: *Problem Based Learning (PBL), Computer in Education, dropout rate.*

1. Introduction

The growing demand and shortage of IT professionals should reach, by the year 2014, about 45,000 unfilled jobs. According to studies [1], Brazil will need approximately 78 thousand professionals by the year 2014, but will graduate only 33 thousand students. This event occurs due to high dropout rates in computing-related courses. At the year 2010, dropout rates reached the mark of 87% according to a research conducted by the Brazilian Association of Information Technology and Communication (AssociaçãoBrasileira das Empresas de Tecnologia da Informação e Comunicação - BRASSCOM). These numbers have been confirmed by the college courses census conducted by the National Institute of Studies and Research (Instituto Nacional de Estudos e Pesquisas Educacionais - INEP) of the Ministry of Education (Ministério da Educação - MEC) and are shown in Table 1.

Table 1. Dropout's percentage (Dropouts/Enrollments) in computer-related courses [2][3]

	PRIVATE		PUBLIC	
SUPERIOR DEGREE COURSES	**2001**	**2006**	**2001**	**2006**
Computer Science	9.83	11.75	6.59	8.57
Computer Engineering	8.31	14.15	5.24	4.20
Information Systems	12.76	10.06	4.91	11.38
Licentiate in Computer Science	13.79	14.39	9.09	8.49
Technologist	9,10	12,58	9,92	11,60
Others	15,65	15,16	11,43	13,41

The mathematics subjects, especially those related to the Differential and Integral Calculus, are also crucial for building the knowledge base required in courses of exact sciences, mainly to improve the logical reasoning. Thus, the performance of students in these disciplines would be essential, but this is not observed. Currently, students join the educational institutions with severe disabilities on basic instructions, which results in a difficulty to follow the course subjects causing loss of interest; factors that may aggravate the process of evasion in the mentioned courses.

The paper is divided in three parts: the first part analyses the Reprobation and dropout rates of the courses in the computation area. At the second moment, the study presents a possible solution to this problem through PBL (Problem-Based Learning) as a way to keep students motivated in order to decrease dropout rates or difficulties encountered by them. Finally, there is a conclusion and future works of the research.

2. Brazilian Drop-out Rates

According to a study realized by reference [4], the courses of Science, Mathematics and Computing, at the year 2005, had an annual dropout rate of 28%. This rate was above the overall Brazilian average, which was 21%. These rates were also confirmed by inquiry presented by the Brazilian Ministry of Education and the National Institute of Studies and Research (INEP) in the Census of Higher Education about the Computer courses, where the national dropout average was 28% [5]. For students [6], the desertion means in their own words, "putting money in the trash" (at private schools), an unfinished course and a "lost time of life". However, for the labor market of the IT area, which is lacking qualified professionals, it is one less vacant job occupied. Researches [7] pinpoint three reflections of unoccupied job slots: first, the phenomenon affects negatively the absent students, since they have their chances of completing graduation reduced. Dropouts also causes reflections in the institutions, threatening the economic viability of the same, bringing risks to them and to the students who keep attending the course. Finally, the desertion have a negative influence on the country itself because of losses on training investments of skilled labor and affecting the productivity of the economy as a whole.

As presented on Table 1, it is possible to perceive high desertion rates in computing-related courses. Ribas [8] after interviewing the students that participated in the research, tried to explain these high numbers. The main reasons are:

a) The teaching of the theory apart from practical aspects does not prepare student adequately for their career;
b) Learning deficits of basic subjects (mathematics);
c) Lack of information when choosing the course on the university entry exam;
d) Prevalence of behaviorist instructional model based on lectures, exercises and memorization techniques;
e) The student tends to think that he or she will develop games, but faces a heavy content of calculations and mathematics, fully unbound of his life experience.

In contrast, Prietsh [2] explains the phenomenon in the following way: “failing and dropout have a direct relation to the subjects that are the gateway to the course, i.e., Logical Reasoning and Computer Languages Studies (algorithms), making it difficult or even preventing the completion of the course. Thus, this first contact can cause affinity or revulsion - which happens way too often. According to the survey conducted by the authors of the study at the Federal University of Mato Grosso (Universidade Federal de Mato Grosso - UFMT), the specific subjects of computer science have a high failure rate, as seen at the first two years of the course.

e first two years of the course.
Table 2 and Table 3. Note that Calculus I, Logic, Data Structure, and Programming II, have a reprobation average of 40.3% only in the first two years of the course.

Table 2. Percentage of Failing Students at the first year [2]

	SUBJECT	% AVERAGE OF FAILURES
1	Calculus I	56.99
2	Computing Algebra – Analytic Vector and Geometry	49.60
3	**Programming I**	**48.44**
4	**Logic**	**47.03**
5	Instrumental English	25.20
6	Experimental and General Physics I	24.02
7	Portuguese – Reading and Text Production	22.56
8	Brazilian Education History (Optative)	21.62

Table 3. Percentage of failing students at the second year [2]

	SUBJECT	% AVERAGE OF FAILURES
1	**Programming II**	**34.66**
2	Calculus II	31.55
3	**Data Structure**	**30.97**
4	Linear Algebra	30.36
5	Object Oriented Programming (Optative)	20.48
6	Computer Architecture and Organization	15.78
7	Experimental and General Physics	11.89

After the academic approach, we present a brief overview of the technology market in Brazil, especially in the sector of Information and Communication Technology (ICT). This area has greatly increased in recent years and has good prospects to keep growing. Brazil is now the fifth largest market on ICT and the seventh largest in Information Technology (IT), according to BRASSCOM (Brazilian Association of Information and Communication Technology). Furthermore, according to research from IDC Brazil, commissioned by BRASSCOM itself, the country is among the four largest ICT markets in terms of IT spending, and has surpassed the UK, Germany and France over the last two years. In 2012, the ICT market spent about U.S. $ 233 billion, representing 51% of the total investment in Latin America.

Following this same fortuity, Brazil's goal is to achieve, by the year 2022, the third position in the ICT market, according to BRASSCOM’s study. For this, there is a need to reach a close to $ 430 billion, almost double the current spending on ICT. Regarding IT, the goal is to reach the fifth position by 2022. In this context, the general coordinator of software and IT services of the Ministry of Science, Technology and Innovation [1], said, "The Brazilian software market is expected to grow 400% over the next ten years". It is also deserving of mention recent TI Major Program, launched by the government in 2012 with the aim of promoting the software industry and IT services, with an expected investment of 500 million dollars for the period from 2012 to 2015.

Parallel to the market growth, there is also a growing demand for professionals. According to Antonio Gil, president of BRASSCOM there are 2.5 million people employed in the industry today, and there will be demand for a million more in the next ten years. According to a study conducted by the association itself[1], over 78,000 job vacancies in information technology will be available in the country until 2014 in the Federal District and other seven states: São Paulo, Rio de Janeiro, Paraná, Rio Grande do Sul, Minas Gerais, Bahia, and Pernambuco.

As explained before, there is an increasingly greater number of jobs being offered, but, as shown on Figure 1, the amount of graduates remain stable. The question to be considered is not only the admissions and graduating (input / output) of students, but also the time spent on the course due to the difficulties encountered along the way. This difficulty is shown at Figure 2, where it can be noticed that the large majority of students are late in the course completion. However, in spite of the extremely favorable moment for IT professionals, there is a discouraging reality: companies are having increasingly difficulties to find and hire professionals because of this lack of professionals in the market. If we consider the study by reference [9], which analyzed the number of employees in occupations related to software and IT services and productivity and revenue generated from their work, the reality is even worse. According to the study, there will be an increasing shortage of IT professionals over the years, with a deficit of about 140,000 professionals in 2013.

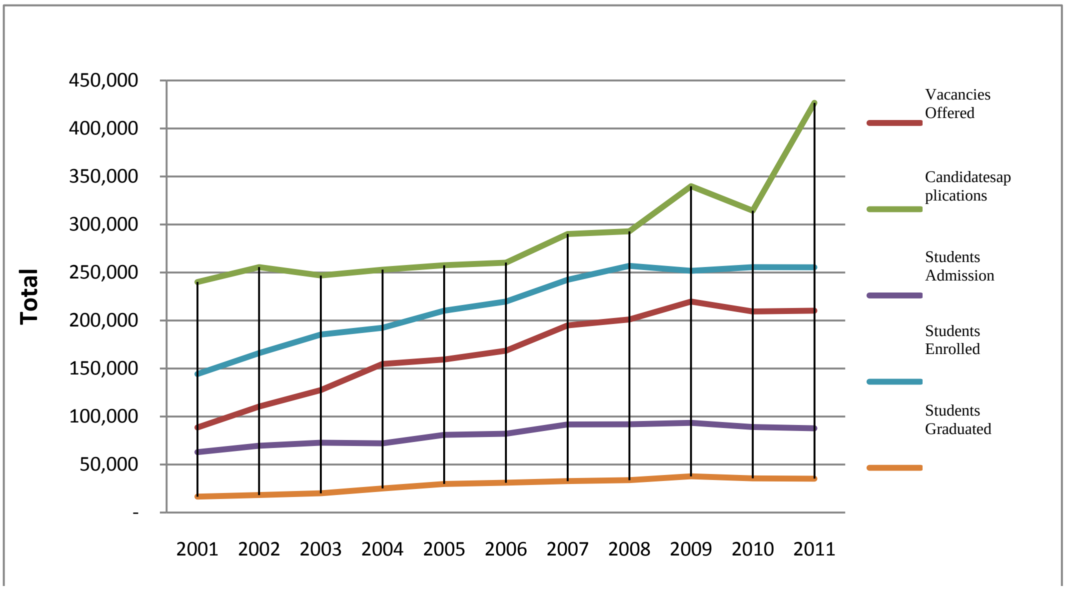

Figure 1. Totals of vacancies, enrollment admissions and graduations in Computer-Related Courses

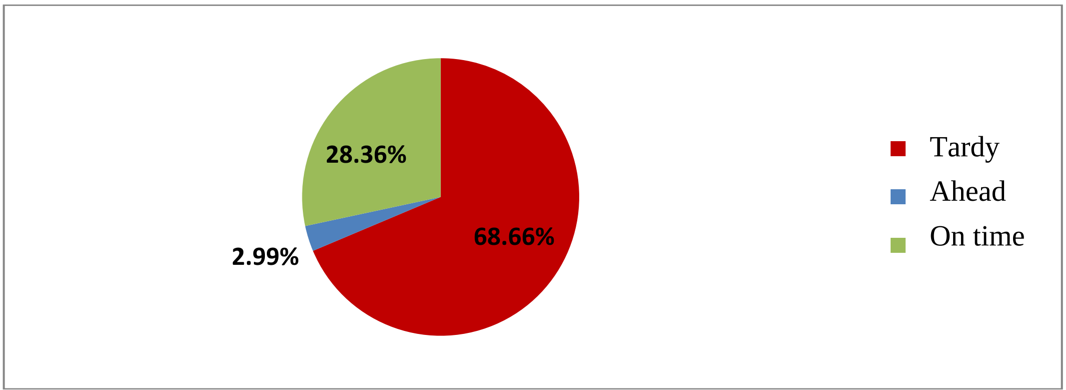

Figure 2. Percentage of students and their status along the course

Based on this scenario, we can affirm that the courses related to the area have failed to follow the growth of the market and its needs for professionals. Reference [10] quotes a study conducted in the United States, which indicates that the growth of vacancies available in the labor market and the difficulty in occupying the tables are due to the decrease in 60% of incoming freshmen of the course of Computer Science from 2000 to 2004. The author provides a comparison with the situation in Brazil, where "the 2008 scenario projected 296,000 job openings in IT while less than 50,000 students completed courses in the field of the exact areas".

With this information, it is possible to establish a relation between the problem pointed and the dropout rates of students in the area, considering that this affects directly the number of graduates in these courses and thus decreases the number of professionals available in the market. According to the same study from BRASSCOM, college dropout in the area can be considered very high for a market with such demand. Sergio Sgobbi, director of Education and Human Resources of BRASSCOM, ensures that the shortage of IT professionals can be justified by the abandon of students in higher education in Brazil. He added, "the competition to enter the course of IT is low, and many of them come to graduation with little basis in mathematics, for example, because of deficiencies in the primary and secondary levels. Over time, this aspect decreases student's interest for the area".

From the situation presented, the author researched a different path to follow as an alternative to reduce this problem, for it is noteworthy that the difficulties presented by the students in the subjects listed cause discouragement, failure and dropout from courses.

3. PBL (Problem-Based Learning)

The knowledge of the area of algorithms is one of the major activities of IT professionals today. It is known that the formation of programmers is a complex process with a number of difficulties such as low ability in problem solving, construction of computational thinking and especially the lack of motivation to perform these tasks. The important when validating the context involved in this issue, related to programming learning is to help students develop the ability to solve problems, the ability to abstract the solution of a problem, the problem domain and finally, knowledge of procedures for the resolution of such computational problems. One of the major disadvantages of the traditional way of teaching algorithms is the difficulty to motivate students to make them interested in the discipline and to understand that the subject is important and essential as a basis for the whole course.

One way to foster the development of effective activities in the discipline of algorithms is grounded in a strategy that tries to seek and stimulate problem solving in a motivated context. In this scenario, there are studies [11] which indicates the use of games as an effective tool to teach algorithms, both for fun and to motivate the student, making the learning more enjoyable and, consequently, increasing retention capacity, by exercising the intellectual and mental functions of the player. Besides gaming, simulation tools also have high motivational ratios in this context, since the student, by this method, can visualize his actions on the activity of programming instantly, identifying the steps needed to achieve a result where, for example adds or removes objects in the environment.

A possible solution to the exhaustion of the current model for the training and teaching of theories and concepts in undergraduate programs is the use of PBL (Problem-Based Learning) [12]. PBL emerged in the 1960s in the medicine course of the McMaster University in Canada and has since been used in various areas of knowledge. It's principles are known as robust because it uses a methodology of collaborative, constructivist and contextualized teaching-learning, using real-life problems (real or simulated) to initiate, motivate and focus the learning of conceptual, procedural and attitudinal knowledge [13].

This methodology is applied through problem-situations to initiate and motivate the learning of the main concepts and theories, the development of skills and attitudes in the context of the classroom, without the need of existing disciplines exclusively for this purpose [13]. The practice of PBL has been used often in a hybrid manner to the conventional system of education, i.e., the course is composed of a main core (core problem) where students can get the solution of this problem in the course of the discipline or through smaller projects i.e., isolated problems at different times during the course. It is pertinent to motivate the student to exercise the features and abilities necessary for the development of computational thinking and logical, essential to algorithms building.

PBL is a teaching methodology that uses real-life problems to stimulate the development of critical skills and problem solving through assimilation to achieve a goal: the proposed resolution of the problem. It follows the theories of Ausubel ("subsumers"), Bruner's intrinsic motivation, the autonomy of Dewey, Piaget, Rogers, Skinner, Burrows (pioneer on PBL) and cognitive psychology of how knowledge is structured, or in other words, how they are accessed with less or more difficulty, in addition to a restructuring work by the students of their already acquired knowledge [13]. These principles of PBL are shown in Figure 3.Learning through PBL helps students access the knowledge in their memory, through contextualization so that there is an increased cognitive structure to easily access similar memorized problems. The impulse of the student to set personal goals in problem solving, strategy choice and assessment of the problem and the educational process provides a self-regulation, making the learning process faster.

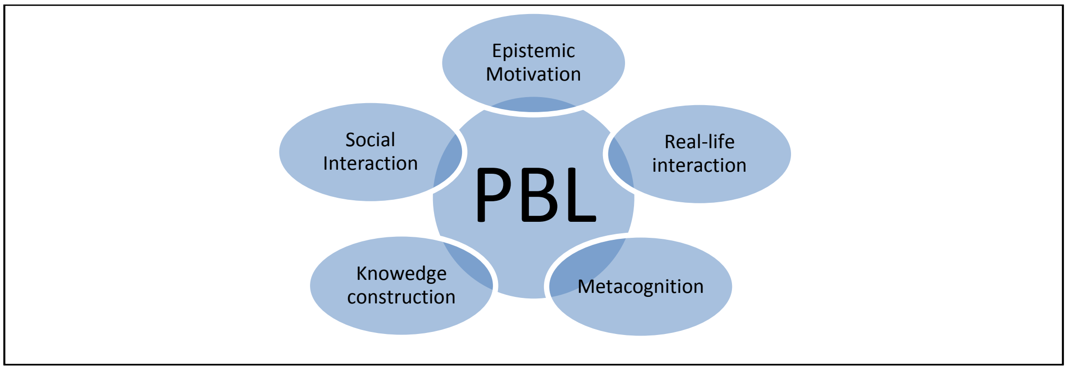

Figure 3. PBL Principles [13]

4. State of the art and preliminary proposal

Through the emergence of PBL courses in the health area, it is clear that its principles proved to be robust enough to allow its use in teaching of the other areas of knowledge. An example of this statement is the work of researchers from the National University of Ireland with the implementation of this methodology of teaching to freshmen in the Course of Computer Science of the institution. The motivation of the research came about due to the high number of dropout students that reached values of up to 27% of enrollments.

Another survey conducted by Souza [14] which describes and performs an implementation of this teaching methodology in the class Introduction to Computer Science in Bachelor Degree in Chemistry at the State University of São Paulo. The study concluded that most students believed that they developed attitudes and skills while studying with PBL, and agreed that the methodology allowed them to formulate hypothesis and compare different ways of solving a problem and achieve the objectives proposed by the discipline.

Although PBL has been designed for medicine teaching, its principles have been shown to be sufficiently strong to support its use in others areas of knowledge" and in other educational levels [13]. Thus, the author of this thesis proposal seeks to investigate the application of PBL in Computer technologist courses in programming disciplines (one of the factors responsible for the high dropout rate), because Its approach and student's profile are different in several aspects, such as a teaching more focused on technical training, aimed at people who want quick access to the labor market with a focus on career due to few theoretical disciplines, and sometimes dependent on the financial resources of the family. These characteristics constitute a different student profile in the classroom, i.e., motivations, attitudes, and performances comparing to other courses, like Bachelor and Licentiate Degrees.

5. Conclusion

PBL is a teaching methodology that contains several ways to create learning opportunities for students. In recent discussions in the literature, there was little and superficial revisions about the possible ways to implement PBL in higher education [12]. A recent study that compared a course using PBL with another conventional course analyzed the academic life of the student, from it ingression to professional life. The results indicated that the PBL prepares you better for life and that there is a strong relationship between the subjects studied at the university.

The reference [4]adverts that the majority of the Brazilian's colleges and universities do not have or maintain in a regular basis the dropout rate monitoring. Institutions should keep track of these numbers and follow the academic life of their students to discover the efficacy of teaching. Which methodology works, which one does not? Is PBL a way to retain the students in classrooms? These questions are the main objective of this study.

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Presenter: This paper is presented by Dante Augusto CoutoBarone

Unconventional Energy Resources: New Challenges in Research and Education

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Abstract

In the current century, natural gas from conventional and unconventional reservoirs has become the most important fossil energy resource and also an important energy fuel in general. Special importance is related to unconventional natural gas: due to ease of transport or transmission, use, but also because of low carbon dioxide emissions from burning natural gas. Significant increase in gas consumption, in all regions, will be marked in the energy sector. The exploration research issues of unconventional gas reservoirs have been discussed recently in many conferences and journals, but the knowledge about the technology is still very low. The public acceptance of this technology, technical, organizational and economic challenges related to exploration, documentation of resources, exploitation and development of shale gas technology, are discussed in this paper. Introducing new pro-ecological procedures and technical modifications for minimization of environmental impact of technology have been presented. The full understanding of the technology and its environmental impact is a big challenge for society and education. This study explains some important aspects of the extraction technology, new research & educational issues.

Keywords: *unconventional natural gas, shale gas, research, public acceptance, environmental impact, education.*

1. Introduction

The most important factor in the development of natural gas production is a breaking-through technology of gas extraction from unconventional sources, successfully implemented in the USA in the last few years. That gas production technology, improved over the last decade, is a reference point for the American economy [1-4]. The technological novelty lies in the way "unconventional" gas becomes exploitable locally and globally with the use of advanced technology. The technological achievements can be perceived from the point of view of civilization changes (local access to gas resources, limiting of CO_2 emission). Natural gas is one of the most desired energy carriers in the World, having a higher level of social acceptance than other energy (e.g. nuclear energy). Considerable increase of gas consumption in all regions will be well received in the energy sector. The development of gas-energy over the last ten years was caused also by [5-7]: application of Combined-Cycle Gas Technologies (CCGT), reaching a high efficiency of cycles – over 50%, lower capital and extraction cost with shorter time of building power plants. Natural gas may be an important energy source for the transition time towards a low-carbon economy. The progress of development of shale gas industry in the USA shows also their impact on the reduction of CO_2 emission in the years 2008-2012 (see fig. 1) [4].

2. Unconventional Gas

What is “unconventional gas” and “conventional gas”? Conventional gas is typically “free gas” trapped in multiple, porous zones in various naturally occurring rock formations such as carbonates, sandstones, and siltstones. Unconventional gas is trapped in geologic formations with very low permeability. Reservoirs mainly include shale gas, coal bed methane, and tight gas. The hydrate deposits are an additional (largest) unconventional gas resource [2, 8]. Hydrates are structures of water/methane clathrates – usually in the moderate and deep water - a commercial technology of extraction will probably be ready in the next 20 years. The example of an extraction scheme for natural gas formation in porous rocks (conventional & unconventional) is presented in the figure 2 [9]. These types of unconventional rocks have different characterization [1-3, 7-8]:

1. Tight gas - gas in reservoirs with low permeability (from <0.1 mD to < 0.001 mD) contained in pores with limited connections between them
2. CBM - gas (methane) in coal-beds, both in the free form in the cracks, as well as in the form of adsorbed
3. Shale gas in the clayey-mud rocks (shale gas). The basic substance constituting the organic layer generating the gas and oil is kerogen. Gas remains in the bedrock, does not migrate into other layers.

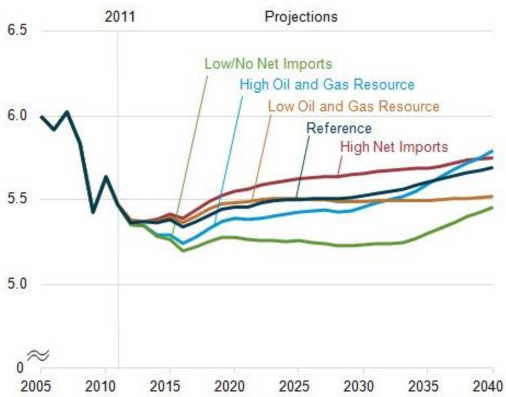

Figure 1 Impact of shale gas extraction in the USA on CO2 emission (emission Gt CO_2 vs time) reduction in years 2005-2011) [4]

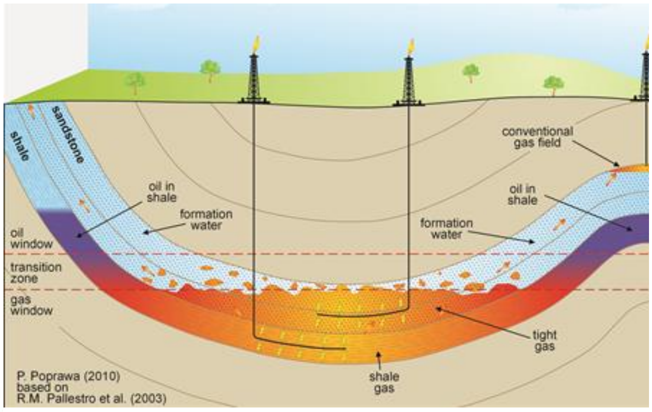

Figure 2 Scheme of natural gas formation in unconventional and conventional reservoirs (scheme of extraction of gas using horizontal wells in shale gas deposits) [9]

The gas from unconventional deposits is usually extracted using horizontal well technology and multiple tracking (e.g. shale gas, tight gas). Unconventional natural gas far outweighs conventional and may constitute an important energy reserve for humanity, taking into account significant carbon dioxide emissions when burned by the coal, brown coal, oil and its derivative industries. The location of unconventional gas resources in the world is presented in figure 3 [1]. In the last six years the daily production in the USA increased ten times (up to 30 BCFD (from 0.8 BCMD)), which is about 40% of world gas production [4]. Estimation of Resources in Place, Technically Recoverable Resources (TRR), and Economic Recoverable Resources (ERR) is still a challenge for geologists and reservoir engineers where theory, experiment and practice is connected [3,10] (see fig.4). The most important geologic information, which is needed to prepare a more general analysis for location of possible 'sweet spots' for extraction processes are discussed in Jenkins et al. [11]. This quantity will be lowered by the introduction of new technologies [13]. At present they are hardly ever used in the fracturing operations on behalf of friendly chemistry ('green additives'), known from chemicals used in the food industry [3, 13]. The important factor stimulating origin of fracture formation is the presence of silica or carbonates in the clayey rocks.

3. New methodology of research in shale gas exploration-academia/industry/society feedback

The technological capabilities of shale gas production have been and still are the subject of intensive research in the USA and in Europe. Future shale gas production in European nations will have significant strategic, economic and (geo) political implications. Extraction of unconventional gas is an intensive industrial process, imposing a larger environmental footprint than conventional gas development. The wells need techniques like horizontal drilling and "slickwater" hydraulic fracturing to enhance the flow of gas from the well. Horizontal wells - in shale gas reservoirs - generally run in a perpendicular direction to the direction of maximum horizontal stresses. This creates a greater likelihood of cracks.

Fracturing additionally generates cracks allocated along the borehole, increasing surface contact with the shale and thus intensifying the flow of gas. The fracturing process consists of pumping under high pressure a narrow stream of low-viscosity water-based liquid (slickwater-type) [12-15]. “Slickwater” covers water with drag reducing agents - substances for the increase of pumping above 9 m^3/min. The pumping rate of such a solution may even be 15m^3/min. The 'slickwater' technology usually makes use of a greater quantity of water than the mixture, i.e. from 4 000 m^3 to 20,000 m^3 for fracturing in one well [12, 13]. Unfortunately knowledge about physics of the extraction process is still in its infancy.

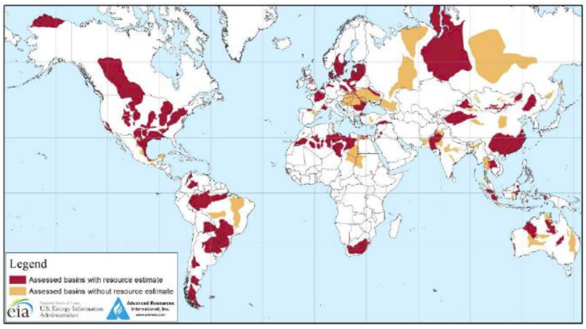

Figure 3 Location of most important shale gas resources in the World [2]

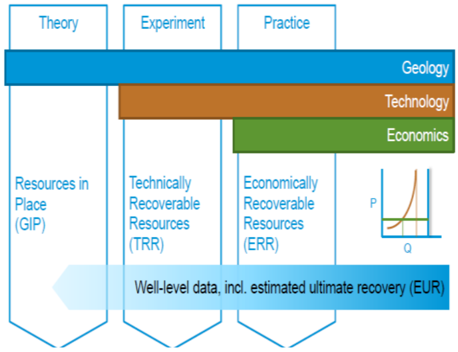

Figure 4 Key drivers for unconventional gas extraction [3]

The transport physics in shale reservoirs account for several non-Darcy flow types. In order to understand the limitations of classical flow physics it is necessary to include characteristics of three additional transport types [16]. Desorption in the matrix bulk: surface phenomena governed by Van der Waal’s forces (modelled by the Langmuir isotherm); classical diffusion in the bulk and within the matrix pore space (Fick’s Law); Knudsen diffusion in nano pore space: beyond a threshold pressure. The Knudsen Diffusion, when present, tends to increase the apparent permeability of the system at the time. Existing simulations do not cover this transport process, and are thereby rather conservative on that aspect and should be improved in the coming years.

The conventional research methodologyy applied to classic gas engineering has to be modified. *The new complex methodology related to research & education in sustainable shale gas extraction operation* consists of several key elements:

1. research on geology, geophysics, petrophysics, desorption, diffusion, flow mechanisms description;
2. new technologies in completion and fracturing;
3. new ecological procedures required by local, state and standard (best technique);
4. new challenges in logistics operations during gas extraction;
5. challenges in multidiscipline education of experts in development technology (geologists, geophysics, drillers and drilling engineers, gas, reservoir engineers, hydrogeologists, chemical engineers); All of those experts should be informed about basic processes relevant to the extraction technology.

A work flow related to shale gas exploration process is built using four principal steps:

1. Exploration (geology basin analysis, seismic interpretation, exploratory drilling, risk estimation)
2. Evaluation (pilot well drilling, stimulation, pilot gas production, economic evaluation)
3. Delineation (estimation of range of sweet spots, infrastructure planning, reserves evaluation)
4. Development (commercial drillings and stimulation, commercial production)

A new systematic research methodology of exploration and development of shale gas reservoirs (see workflow above) is based upon existing accessible geologic material consisting of the following steps:

1. Data gathering (specific data on the horizons, 2D, 3D seismic data acquisition, well logs, etc.)
2. Data analysis (analysis on multi-variate level to identify the possible correlation between parameters)
3. Uncertainty identification & Mapping
4. Reservoir modeling (analytical models, SRV simulation)
5. Reservoir management plan (reservoir management plan with mitigation options)

This above methodology of research (linked with methodology of research/education) has been applied in Poland during the exploration phase. The second phase of exploration in Poland is still ongoing. Still more information related to the specific properties of shale rocks and understanding of flow physics is necessary to implement present technology in different geologic conditions. The application of this new methodology will be observed and modified if necessary.

4. Novel elements in technology

Evaluation of sustainability of shale gas exploration and production on a transparent and scientific basis is still missing in Europe. The following important elements have to be considered by analysis of the development of extraction of gas in the next years: increasing supply, reducing the cost of production, increasing E&P efficiency and lower environmental impact. The IEA estimates that the global energy mix will change from 21% to 25% by 2035 (50% increase in demand), overtaking coal. Estimates of Polish resources vary from 1 Tcm to 3.9 Tcm [1]. The other exploratory work in Europe is initiated in the UK, Ukraine, Spain, Portugal, Netherlands, Lithuania, Hungary and Romania. Various statements on costs for shale gas production – some say exploration costs up to three times higher than in the US, others say costs are 1.5 or 2 times higher than conventional exploration. Development costs of greenfield production of shale gas are in range from USD 2-9/MMBTU (70-320 $ per 1000cm). In the US production costs currently range from USD 4-6/MMBTU (140-210 $ per 1000cm) (as a rule of thumb production costs of USD 4/MMBTU ((140 $ per 1000cm) are said to be economically reasonable). In assessing the cost effectiveness of extraction projects the ratio of economically viable recoverable resources (ERR) to the technically recoverable resource reserves (TRR) is taken into account. In the US it is about 60% and depends on the cost of field development, drilling costs and gas prices [10]. In relation to the primary (initial) resources in the bed TRR ≈ 75% and ERR ≈ 30-40%. Recent reports regarding technological change point to the development of clean, high-efficiency natural gas extraction technology opportunities for the exploitation of deposits of over 55 % recovery [13]. Fracturing consumes large quantities of water, up to 20 000 m^3 per well. This involves considerable environmental problems. It seems that one of the biggest environmental challenges is the treatment of water used for hydraulic fracturing. The modification/development of this technology has to be addressed to the different geology of shale deposits. The following fields of operation may be important for the next ten years (modified from reference [8]):

1. New technology of stimulation of wells (shale gas/tight gas/CBM) (e.g. with energized fluids)
2. Fluid Systems (N_2 Foam, initial slickwater, XL/Lin gel treatments, hybrid & reverse hybrid)
3. New post-fracking fluid recycles /new waste utilization (reduction of hazards/emissions)
4. New materials for stimulation/New drilling fluids/new completion fluids (shale gas/tight gas/CBM) (increasing of process efficiency)
5. New propant type, impact of delivery and intra-zonal distribution, new fluid additives (KCL, new surfactants, new friction reducers, new biocide, large target interval impact, impact of rock quality)
6. New environmental monitoring process tools. New tools for extraction process design (shale gas/tight gas/CBM)
7. Process Improvement in drilling and completion (elimination of OHPS, elimination of CBL, limited bit & scraper, new applications of coiled tubing technique, new pads)

5. Selected remarks about complexity problems in shale gas exploration, social acceptance problems & general education about shale gas production process

The scale of development of unconventional gas extraction can have important implications for local communities, land use and water resources. Serious hazards, including the potential for air pollution and for contamination of surface and groundwater, must be successfully addressed. The recent initiation of exploration for shale gas in European countries raises questions about regulations (national and EU-wide) that should be addressed before commercial production starts. Also, public concerns about the environmental impact of shale gas drilling, as expressed by environmentalists and local communities, need to be addressed. Greenhouse-gas emissions must be minimized both at the point of production and throughout the entire natural gas supply chain. Improperly addressed, these concerns threaten to curb, if not halt, the development of unconventional resources. The change of technology of unconventional gas extraction during the last decade opens discussion about world dissemination of extraction technology. The public opinion usually has limited information, probably influenced by the “GASLAND” film. The topics relating to shale gas are still contentious in the EU. A more scientific discussion is only at the University/Research Organization level.

Several negative environmental impacts related to shale gas exploration process are presented in many Internet publications – this information is usually distorted (or false): Mordant substances necessary for the "liquefying" of some parts of the shale in order to extract a gas are released in the air; Pathogenic, mutagenic and carcinogenic substances, dangerous for human health, are released, the greatest part of which cannot degrade or neutralize naturally; Breaking the shale gas provokes natural disasters like earthquakes; Explosive and flammable effluents are released during the effervescence as well as during the refinement on spot; High levels of radiation are determined (2 000 times above the norm) around the places where the shale gas has been extracted; Air, soils and water are polluted; Several academic institutions still investigate possible environmental impact of shale gas technology, but there is no a single evidence of violation of the right to live in healthy and favorable environment caused by the shale gas technology. Many aspects of possible environmental degradation have been thoroughly investigated by various researchers and universities (e.g. MIT [2], state agencies (e.g. EPA) and European NGOs). In addition, a special environmental report prepared by a scientific consortium led by PGI NRI (Poland) [18] has not found out any of the negative effects on the environment which are mentioned in the petition. Similarly the research currently led by the PGI-NRI consortium together with the AGH University and the Gdansk Technical University does not confirm important environmental damages. The main aim of the works of the consortium led by the PGI-NRI was to assess environmental impact of hydraulic fracturing carried out in August 2011 on the Lebien LE-2H exploratory well operated by the Lane Energy Poland company. The studies comprised seismic monitoring, measurements of gaseous emissions and noise and analyses of soil gas, hydraulic fracturing fluid and surface and ground water.

Nowadays the environmental hazards were much lower than 5 to 10 years ago [13-14]. The basic documented cases encountered during drilling and gas production from conventional & unconventional sources in the USA were listed by the MIT [2]. Among 43 cases, statistically analyzed in 2006-2010, about 50% were contaminations of groundwater (gas migration to water, see also information about the methane occurrence in shallow aquifers in the USA [6, 7], being a result of drilling operations). As mentioned above, such events may take place as a consequence of insufficiently protected drilling columns cutting off groundwater fluxes and natural gas migration to these wells. Another environmental hazard more frequent than the others was connected with leakages and contamination of oil products on the surface in the drilling site/rig. The second major types of incidents are on-site surface spills (according to the MIT [2] report). No cases of direct invasion of shallow water zones by fracture fluids during the fracturing process have been recorded. These incidents exhibit that there have been real issues with the integrity of natural gas drilling operations. The number of incidents should be placed in the context of the several thousands of natural gas wells drilled over the period under review. The discussed cases should be compared and analyzed with the immense number of gas wells drilled in the US. – tens of thousands each year. As a result, we conclude that the impact of these types of environmental incidents is generally moderate. Obviously attention should always be paid to all environmental impacts as they may indirectly, have some effect on human health.

6. New post graduate study "Unconventional Natural Gas Extraction" (AGH) – educational challenge - link between research and classic education with real feedback

In addition to unconventional gas research at the AGH University of Science & Technology in Cracow it was necessary to start an education programme in issues related to this topic. One element of the education is a postgraduate course in unconventional natural gas started in 2012. The research and development of new technology in this engineering area requires strong cooperation also in the education of engineers (see Fig. 5). The progress in this technology is quick, so many of the classic educational programs have to be modified in a short time. More than 15 years after the Magna Charta Universitatum was signed in Bologna (1998), which was fundamental for creating new educating structures in Europe and the EAHE (European Area of Higher Education). The benefits of the two or three-step studies are the following: shorter period of the first cycle, possibility to choose the type of studies in a more flexible way, adjusting for interest and life purposes of the student, possibility of changing universities during the period of studying and collecting confirmations of achieving knowledge (ECTS). This system prefers a more practical side of the engineering studies, after the first cycle one can achieve the first diploma allowing to work as an engineer. The benefits of this system also include promoting and achieving double diplomas which are signed by both universities and are assisted by educational programs like Socrates/Erasmus. The main criteria for education of engineers in these new energy extraction topics are:

- obtainment thorough and complete education on a scale of fundamental sciences with likewise technologies;
- necessity to support continuing and supplementary education in interdisciplinary areas;
- preparation of petroleum engineers to meet a new emergent discipline – energy engineering.

The new Program assumes to create a system of vocational training with a possible system of postgraduate studies in the mixed system (conventional & distance learning) system. The study includes 270 hours classroom and 60 ECTS in 15 courses plus a final project "Integrated project - management of exploration and management of gas reservoirs". The syllabus of this postgraduate study ("Unconventional Natural Gas Production") is presented below:

1. GEOLOGY of unconventional oil and gas reservoirs (4 ETCS)
   Petroleum system - the general characteristics of its components, scheme of hydrocarbon reservoir formation. Hydrocarbons genesis – scheme of natural hydrocarbon formation in petroleum sedimentation basin; main stages of the generation - the role of temperature and pressure. Bedrocks - types and efficiency characteristics (TOC, kerogen, Ro, generation potential). Primary and secondary migration of hydrocarbon processes and its mechanisms. Unconventional reservoir rocks - geological characteristic and conditions of the hydrocarbon production. Sealing rocks. Formation of reservoir traps for hydrocarbons and their classification. Hydrocarbon reservoirs, classification of crude oil and natural gas.

2. PETROLEUM GEOCHEMISTRY for UNCONVENTIONAL RESERVOIRS (2 ETCS)
   Organic and petroleum geochemistry. Oil and natural gas - composition, definitions, geochemical-genetic classification criteria. Bitumen and kerogen; Bedrock faces; Oil shale Geochemistry. Natural gas and oil genesis in the light of research results of molecular and isotopic composition. Reaction kinetics of hydrocarbon generation and expulsion. Pyrolytic method's application to evaluate the hydrocarbon potential of the bedrocks and to determine the kinetic parameters of the reaction to generate hydrocarbons. Hydrocarbon potential of mine coal and its relationship to the natural gas and oil. Petroleum system: from the bedrock to trap, the genetic classification of petroleum systems.

3. GEOPHYSICAL RESEARCH OF UNCONVENTIONAL RESERVOIRS (3 ETCS)
   Seismic (framework, 3D seismic, interpretation), seismic research 2D/3D: seismic vibrators 2D/3D, seismic dynamite 2D/3D, control data processing, interpretation of measurements of low velocity

zone by shallow refraction and microprofile in the hole, a complex geodetic analysis. Geophysics drilling instruments and measurement equipment. Hole measuring-interpreting apparatus type: DDL-CH/PL. Measurement methods. Interpretation Methodology of geophysical measurements. Research on the technical condition of production well. Determination of mechanical properties of rocks: lithology and composition of reservoir rocks.

4. PHYSICS AND RESERVOIR ENGINEERING (6 ETCS)
The main petrophysical parameters of reservoirs. A mathematical model of fluid filtration in porous and fractured porous media. The equation for the flow of low compressible fluid and compressible fluid into the borehole. The gas flow in the shale rock through nanopore network connected with micropores (fractures). Gas desorption and diffusion phenomena in kerogen to the contact surface with nano porous. Flow in micropores and pores. Flow in nanopore, diffusion on the nanopores walls and molecular flow.

5. PVT PROPERTIES OF RESERVOIR FLUIDS (3 ETCS)

Fundamentals of thermodynamics. Properties of real gases - equations of state: RK, VdW, PR, nomograms h-s, specific heat, viscosity, law of corresponding states. Fluid properties - density, viscosity, compressibility. Compression of natural gas. Joule-Thomson effect. Two-phase systems, vapor liquid equilibrium (VLE) of gas condensate and light oil multicomponent system. Recombination of reservoir fluid composition. Thermodynamic tests. Confined nanopores critical properties. Nanopore effects and capillary force effect in VLE.

6. ROCK MECHANICS AND FUNDAMENTALS OF FRACTURING (5 ETCS)
Introduction to continuous media mechanics (the relationship between the distributions of displacements, strains and stresses). The distribution of stresses around the excavation of circular cross section with uniform and non-uniform initial stress state. Rock mechanical properties including tensile strength and triaxial compressive stress state of the original rock (geostatic areas and tectonically disrupted). Fracture classification, hydraulic fracturing methods. Technological parameters determination of treatment process (fracturing pressure, fluid volume flow, fracturing time). Project of multistage fracturing

7. NEW DRILLING TECHNOLOGIES IN UNCONVENTIONAL RESERVOIRS (6 ETCS)
Directional and horizontal drilling. Directional wells profiles and notions characterizing the trajectory of the hole axis. Principles of designing trajectory axis of directional wells. Tools and deflection kits. The drilling cable used for directional drilling. Drilling technology using reel wire. Characteristics and operation of plunge engines. Telemetry measurement systems during drilling. New design of drilling rigs, drilling equipment and accessories. Cementing casing design. Selection of drilling equipment. Selection of drilling tools. Drill string design. Design of mechanical and hydraulic parameters of drilling technology. Perforation and fracturing in boreholes. Drilling costs.

8. MONITORING OPERATION AND ENVIRONMENTAL PROTECTION (4 ETCS)
The main sources of environmental threat in the exploration and exploitation of unconventional resources. Qualitative and quantitative effects of geophysical operations, drilling, completion and exploitation to environmental elements. Materials and fluids toxicity. Drilling waste management (forming during shale fracturing). Waste utilization methods. Air protection, dust and toxic gases emission into the atmosphere. Noise and vibration protection. Soil and water protection.

9. EXTRACTION GAS TECHNOLOGY & FORECASTING OF GAS PRODUCTION (4 ETCS)
Geological identification of potentially productive shales. Engineering characterization of shale reservoirs- screening criteria. Completion of shale wells. Development and performance forecasting. Decline curves. Compositional modelling of gas extraction. Single well vs. multiple well. Single phase vs. multiphase modelling Evaluation of reserves, economics, and development planning.

10. ECONOMICS OF DRILLING AND EXPLOITATION PROCESS (4 ETCS)
Rules for drawing up contracts for drilling. Economic limitations in well constructions and boreholes systems designing. Fundamentals of drilling cost optimization for projects drilled from a single drilling site. Cost analysis of plunge equipment & gas separation and transport preparation. Operating cost analysis.

11. GEOLOGICAL AND MINING LAW AND ENERGY LAW (2 ETCS)
Energy law. Scope of G&M law. Property and mining operational use. Management of hydrocarbon reservoir. Concessions and their types. The movement of the mine. Neighborhood relations and responsibility for damages. Geological Survey and Mining supervision authorities.

12. PILOT PROJECTS EFFICIENCY ASSESSMENT AND DECISION MAKING AS ELEMENTS OF OPERATIONAL PLANNING (2 ETCS)
Cost estimating methods for license management. Economic analysis of gas production from the pilot projects. Evaluation of the possibility of reducing the capital cost (drilling, servicing, surface installation) and operational costs. Sensitivity analysis of NPV, EMV to changes in the medium and long term forecast of gas sales. Risks related to the unconventional gas project economics.

13. LABORATORY MEASUREMENTS OF PETROPHYSICAL PROPERTIES OF ROCKS (2 ETCS)
Petrophysical properties: porosity, permeability, grain density, and saturations (water saturation, gas saturation, gas filled porosity and clay-bound water). Static (triaxial) and dynamic values for Young's modulus. Compressive strength, fluid leak-off, and propant embedment evaluation.

14. INVESTMENT , SURFACE MANAGEMENT & LOGISTICS (2 ETCS)

Development and leading commune land management. Management plans. Linear infrastructure. Water supply. Road infrastructure. Preparation of investment. Logistics of materials supply and use of local road transport. Minimizing the impact of local transport to the environment. Minimization of other environmental risks. Arrangements in the investment process.

15. GEOGRAPHIC INFORMATION SYSTEMS IN SHALE GAS EXTRACTION PROCESSES (2 ETCS)

Data management. Upstream exploration. Field geology. Petroleum land management. Seismic surveys. Surface geologic studies. Spatial well and seismic data integration

16. INTEGRATED PROJECT - MANAGEMENT IN EXPLORATION & GAS RESERVOIR PRODUCTION (10 ETCS)

Integrated project of gas production from unconventional resources. Variant risk management projects, in exploration and extraction of natural gas from unconventional reservoirs.

The presented project of new postgraduate education – started in 2012 will be extended in next year for exchange education program oriented for the European area. The success of education has to be correlated with the research achievements in this region in the next decade.

7. Conclusions

1. Challenges for technological development in Europe are the following: high cost of gas extraction; new infrastructure needed for gas transport and distribution;
2. The presented methodology of research (linked with methodology of research/education) has been applied in Poland during the exploration phase. The second phase of exploration in Poland is still ongoing. Still more information related to the specific properties of shale rocks and understanding of flow physics is necessary to implement the present technology in different geologic conditions. The application of this new methodology will be observed and modified if necessary.

3. Restrictive environmental regulations, large number of protected areas and objects, negative opinions of local administration, bad logistics of supplies, hindered access to water resources - may considerably lower the rate of industrial development of unconventional gas extraction technology in Europe;
4. Education in unconventional gas extraction technology at basic, intermediate and university level is one of the most important elements of a new low-carbon and gas-friendly economy.

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Presenter: This paper is presented by Stanisław Nagy

[1]EVALUATION OF AN ODeL KNOWLEDGE ACQUISITION AND CONSTRUCTION FRAMEWORK

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Abstract

This paper evaluates the utility of a framework for acquiring and constructing technical subject knowledge by learners in ODeL (Open and Distance e-Learning). The emphasis is on knowledge acquisition and construction of activities in total cost management, with an application in cost engineering. Blogs, wikis, chat rooms and other technologies such as scaffolding are employed by course instructors as they facilitate peer support and knowledge acquisition and construction. Before developing any online learning materials, educators ought to be well versed with learning- and ODeL knowledge acquisition and construction principles. The roles played by behaviourist, cognitivist, and constructivist theories to facilitate knowledge acquisition and construction are unpacked. The knowledge acquisition and construction activities of learners are classified by identifying the occurrences of such activities in the building blocks of a previously developed framework of the authors. Critical success factors of parts of the knowledge acquisition and e-learning processes are established, and the generic aspects of such processes are identified through the said framework and a model for presenting a lecture.

1. Introduction

The Open and Distance e-Learning (ODeL) model is gaining popularity owing to its, often cited, *study anywhere and anytime* characteristic [1], [2]. Despite the many advantages brought about by ODeL, it often faces demanding challenges owing to its inherent distance-education component. Some concepts, especially those having a mathematical content (e.g. Total Cost Management (TCM) in an engineering discipline) are hard to adequately convey to students over a distance. Solutions for some instantiations of this challenge have been proposed, notably in the teaching of operating system concepts in Computing [3] and it is envisaged that such techniques may be applicable in the teaching of concepts in TCM. The assimilation of existing knowledge and the subsequent construction of new knowledge from known facts are important skills to be mastered by students. To this end we developed a knowledge acquisition and construction framework for achieving this goal. The framework was inspired by a number of important developments and suggestions in the area of (online) tuition [4] and is reproduced in *Appendix A*. The aim of this paper is to validate the utility of the framework by conducting a costing exercise as part of TCM.

The layout of the paper is: The research methodology and the research questions are followed by a brief overview of the proposed framework and various education technologies that inspired the framework. A model of a typical lecture is presented, followed by a number of definitions and a cost analysis exercise to be used in validating the utility of the framework. We revisit our research questions and conclude with a summary and directions for further research.

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2. Research Methodology

The research reported on in this paper is exploratory in nature in that it evaluates a preliminary and previously developed framework. Such framework was designed through a comprehensive survey of various components and aspects in the literature on acquiring and constructing subject knowledge in ODeL. Further development of the framework will be done through qualitative surveys among students at a large South African ODeL university [5].

3. Objectives of the Research

The purpose of our research is to determine the utility of the framework in Appendix A for assisting students to acquire and construct technical subject knowledge in ODeL. Our research questions follow.

3.1 Research Questions

RQ1: To what extent does the framework in Appendix A assist students in acquiring and constructing technical subject knowledge?

RQ2: What other theories or frameworks may usefully enhance the framework in Appendix A?

4. The Proposed Framework

The framework in Appendix A unpacks how knowledge may be acquired and constructed through e-learning technologies. Critical success factors were identified in the literature and distilled into three (3) phases, namely, Conceptualization, Design, and Implementation. Conveying existing knowledge and the construction of new subject knowledge by students were the drivers of these phases. This is different from other Knowledge Management Frameworks which often address the business world, rather than higher education institutions [6]. The development of a framework ought to facilitate the organising of a complex subject, identifying the relationships between the parts and revealing the areas in need of further development [7]. Hence, we hope that our framework will facilitate an understanding of the theories and practices of knowledge acquisition and construction.

5. Knowledge Acquisition and Construction

Knowledge acquisition is the process of absorbing and storing information into (human) memory. Every learner has to construct his or her own knowledge by processing and accommodating information, attitudes or behaviours into previously existing cognitive, attitudinal or behavioural structures [8]. Using blogs, wikis, chat rooms and other technologies, instructors should be able to facilitate peer support and student knowledge construction [6], [8]. Blogs have been used by online learners to create material reflecting on their learning experiences. These are a means of developing reflective skills which may lead to enhanced learning. A well-designed course should engage students in discussion, criticism and knowledge construction, depending on the level of prior knowledge and experiences of the students. Conceptualisation (Level 1) in the framework addresses these aspects. Social networking technologies, e.g. Skype, blogs and wikis facilitate collaboration and the sharing of ideas and experiences. Some scholars claim that group-based collaborative learning enables the development of learning communities in the short term and communities of practice in the long term [6], [8]. This research suggests that the affection, inclusion and sense of solidarity of a group are important characteristics in the successful social construction of knowledge online, hence the Teaching and Learning Village component in the framework.

Interaction has always been valued in distance education and [9] first discussed the three most common forms of interaction in distance education which they claimed to be responsible for deep and meaningful learning: student-teacher, student-student and student-content interaction. These were later expanded by [7] to include: teacher-teacher, teacher-content and content-content interaction. The Web provides new opportunities in the form of education in virtual laboratories and online computer-assisted learning [10].

6. Understanding How Students Learn

The quest to understand how students learn has been a subject of research (and study) for a long time. Recently this is being compounded by the need to understand how students learn in an online environment. An account of some of these activities appears in [11].

7. Theories of Learning

The theories of behaviourism, cognitivism and constructivism all contribute to the Knowledge Acquisition and Construction Framework. Each may be applied at appropriate stages within the framework, contributing to the theory of learning in conjunction with the others [12], [13]. Behaviourism focuses on observable behaviour; learning is to show a reasonably permanent change in behaviour, while constructivist learning is to see the meaning or significance of an experience or concept [14].

Cognitive science came about as a response to Behaviourism that was influenced much by the works of Ivan Pavlov and B. F. Skinner [15]. According to [14], learning occurs when new knowledge is acquired or existing knowledge is modified by experience. Research in cognitive science confirms that knowledge obtained through activity is more useful than knowledge obtained through pure memorisation [14].

Constructivism is a group of theories that can offer an explanation about how people learn. People construct their own semantics, building on previous knowledge and experience [14]. A Constructivist (teacher) acts as a facilitator or mediator, and helps the learner to discover meaning and understanding. In social constructivism, interaction and collaboration between learners are seen as fundamental to learning with knowledge being co-constructed during peer interaction and discussion [16]. While constructivist theory is aimed at understanding and exploring the ways in which children learn, many researchers and instructors in higher education have applied constructivism to adult learners [17].

The framework in Appendix A gives cognisance to understanding how students learn during the conceptual phase already. Scaffolding during the implementation phase caters for the Constructivist approach where the teacher acts as a facilitator or mediator.

8. Online Learning

[8] Defines online learning as the use of the Internet to access learning materials; to interact with content, the instructor, and other learners; and to obtain support during the learning process, to acquire knowledge and to construct personal meaning. It is anticipated that the use of ICTs (implementation phase) in the framework will play a central role in this regard. A key to successful online learning is to create learning environments that encourage collaboration. The collaborative design element of most Web-based education involves interactivity, resulting in learner-centred instruction [17].

Researchers at the Institute for Higher Education Policy [18] recommended that for effective online education, lecturers need to be assisted in the transition from classroom teaching to online instruction. Also, online pedagogical strategies need to improve in tandem with technological sophistication. [17]. Some researchers believe that e-learning requires a new theory of learning. E-learning is dynamic; it is changing and adapting to new social situations, new politics, new technologies, and new forms of learning [12].The existing theories of learning do not seem to account fully for what happens in e-learning especially the “e” portion. E-learning, therefore, needs a dynamic and flexible learning theory since new technologies and new social practices are constantly interacting with learning [12]. Learning will be seen as an effect of communities and their interaction, hence the idea of a Teaching and Learning Village in the framework.

The use of technology is seen by many academics to be associated with additional work. There is also a lack of support and few well-developed policies for teaching with these systems. We believe our framework could address this challenge in that it makes provision for enhancing the ICT skills of teachers (Lack of human support – assisting lecturers in enhancing their ICT literacy).

9. A Costing Scenario

The following section discusses the format of a lecture which is to be presented in the online medium, to adult distance learners. The format is adapted from [19].

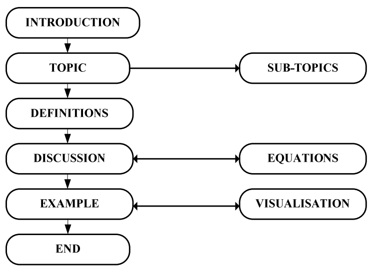

Figure 1: Model of a lecture (Adapted from [19])

Next we explore each of the actions in the model on the strength of an example, namely, a break-even analysis in a manufacturing application.

9.1 Introduction

Break-even analysis is a TCM tool where the cost engineer needs to make decisions on production levels especially in a manufacturing environment. Following some definitions and a discussion, a worked example is used to illustrate the calculation of a break-even point. This is consistent with [20] – learning by example, and the framework in Appendix A. The worked example will be posted as a blog, where after students are required to work out similar exercises and post their answers for the instructor's attention.

9.2 Topic

The topic is Break-even analysis. The topic and related concepts appear in Table 1.

Table 1: Topic and Sub topics

Break-even Analysis	
Sub topics	Break-even point
	Fixed costs
	Variable costs per unit
	Quantity
	Selling price per unit

9.3 Definitions

As per the model, definitions particularly those relating to concepts of cost are presented next. After the discussion and equations, a worked example illustrates the calculation of a break-even point.

Table 2: Concepts and Definitions

Concept	Definition
Break-even analysis	An analysis whereby a business (e.g. a factory) compares its revenues (sales) and costs in order to establish the feasibility of its production lines.
Break-even point	The point where profit is zero, that is, marginal income is equal to fixed costs.
Fixed costs	Costs paid irrespective of the level of production. Example: Rent of machinery, since it does not change from month to month. It normally remains invariant during a particular year.
Variable costs	Costs that vary directly with the number of units manufactured because more input is required in order to increase output. Example: Direct materials or Direct labour in e.g. manufacturing.
Direct costs	Costs that can be traced to a *particular* product.
Indirect costs	Costs that cannot easily be traced to a particular product.
Direct materials	All materials that form an integral part of the finished product and that can be included directly in calculating the cost of the product.
Direct labour	Labour expended to convert direct materials into a finished product.

9.4 Discussion

The literature reveals that the constructivist approach is well suited to online instruction; therefore, constructivism is used in the framework. The other theories remain relevant and any good points from them may be incorporated. Since most distance learners are adults [17], coming up with a winning strategy ought to be easier, given the positive attributes of adult learning groups. It also follows from the literature that collaborative learning and interactivity are encouraged in online courses; hence the above lecture can be conducted online. Students would be encouraged to work interactively in groups and to post their solutions as a group. They would also be expected to participate in, and contribute to chat room discussions on the topic. All these fit in with our proposed framework in Appendix A.
Referring to the lecture layout, in Figure 1, the next aspect addresses equations.

9.5 Equations

Break-even point $= \dfrac{Fixed\ costs\ in\ total}{(Selling\ price\ per\ unit - Variable\ cost\ per\ unit)}$

Break-even units $= \dfrac{Total\ fixed\ costs}{Marginal\ income\ per\ unit}$

Break-even value $= \dfrac{Total\ fixed\ costs}{Marginal\ income\ ratio}$

Example: Activity 1 - The following information is available:

Table 3: Activity 1 - Cost per Item/Category

Item/Category	Amount (R)
Material cost to manufacture 1 unit	4.50
Labour cost to manufacture 1 unit	3.20
Factory rent	4 000
Indirect labour cost	2 200
Selling price per unit	22

Required: Calculate the number of manufactured units to be sold in order to break even.

Suggested solution:

Break-even point $= \dfrac{Fixed\ costs\ in\ total}{(Selling\ price\ per\ unit - Variable\ cost\ per\ unit)}$

$= \dfrac{R6\ 200}{(R22 - R7.70)} = \dfrac{R6\ 200}{R14.30} = 433.57$ units

The break-even point may be represented graphically as in Figure 2:

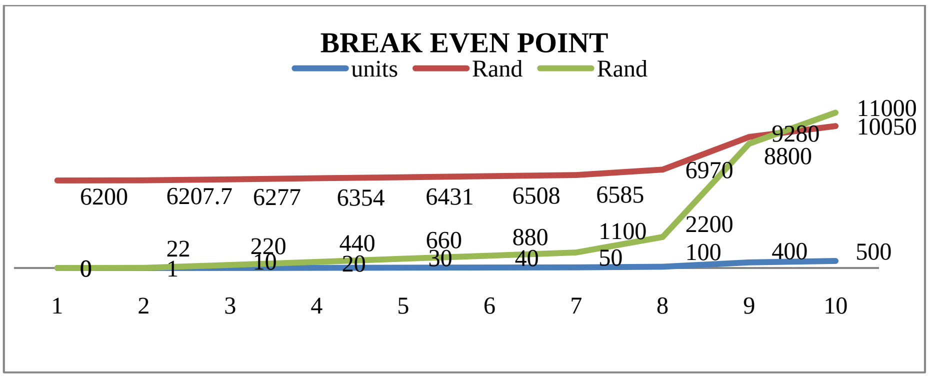

Figure 2: Break-even point

Example: Activity 2 – The following information is available:

Table 4: Activity 2 - Cost per Item/Category

Item/Category	Amount (R)
Materials used to manufacture 20 000 units	200 000
Wages (factory workers)	50 000
Factory rent	90 000
Factory insurance	11 000
Salary (Factory Manager)	23 000
Selling price per unit	15

Required: Calculate the number of units to be sold in order to break even.

For ***Activity 2***, the facilitator could do part of the calculations and leave the rest to the students. For a next activity he/she may decide to let the class do all the calculations, either individually or in groups.

10. Validating the Utility of the Framework

The proposed framework in Appendix A may facilitate a successful execution of the above break-even analysis exercises in a number of ways:

1. *Maintain Hand-writing Skills (Design):* For a first or 2nd attempt, encourage students to write out the calculations by hand.
2. *ICT Tools (Implementation):* Following on the above, encourage students to use a spreadsheet for the above calculations. Ask them to construct the graph in Figure 2 in (e.g.) MS Excel ^{TM}.
3. *ODL Knowledge Transfer (Design):* Make a podcast (voice) to tell, or a vodcast (video & voice) to tell and show how the calculations are done.
4. *Scaffolding (Implementation):* Do a calculation fully for the students over a Skype session, or during a video/satellite conference. Then do another one partially (e.g. ***Activity 2*** above) and ask them to supply the missing details. Then let them do a 3rd example entirely on their own.
5. *ODL Knowledge Transfer (Design) & Learning Experiences (Implementation):*
   (a) During above scaffolding, let them work in groups (Design phase).
   (b) Ask them to construct a learning experience by recording their thinking while performing a cost analysis, either in a group or individually.
6. *Feedback and reflection (Design):* Discuss in the large group how the learning experience in 5(b) above may help them with subsequent tasks.
7. *Practice "endless" repetition (Implementation):* Provide additional examples on the same topic. Ask them to construct their own examples with solutions. For each example, follow a selection of the above steps in the framework.

11. Findings

This paper briefly introduced concepts that were used in the design of a knowledge acquisition and construction framework for learners in acquiring technical subject knowledge. Theories related to constructivism, behaviourism and cognitivism were touched on to model how students learn and construct knowledge. A model of a lecture was adapted from the literature and a case study involving technical subject knowledge was introduced. Our framework was evaluated on the strength of the case study and its utility for acquiring and constructing technical content was illustrated. Some prominent aspects were the use of ICTs, scaffolding, the use of learning experiences and the adoption of a learning environment (village). While the original framework was developed for knowledge acquisition and construction in management sciences, the examples illustrated its utility for TCM in engineering.

12. Research Questions

The research provided answers the two (2) research questions posed above:

RQ1: *To what extent does the framework in Appendix A assist students in acquiring and constructing technical subject knowledge?*

A number of components and activities defined in the framework were found to be useful and applicable for the costing scenario discussed in Section 9. Therefore, our framework facilitates the acquisition and construction of technical subject knowledge.

RQ2: *What other theories or frameworks may usefully enhance the framework in Appendix A?*

Section 9 introduced a model of a lecture in the literature and we showed how this model may augment the activities of the framework. Hence a framework for presenting a lecture (online or otherwise) may be combined with the activities in our knowledge acquisition and construction framework.

13. Future Work

Future work may cover the following: Interactions among the three levels of our framework warrants further strengthening, and improved determinism in the steps to be followed in the knowledge acquisition and construction processes has to be established. The scalability of our framework to larger knowledge areas in the subject has to be investigated. Automation, involving software support should be investigated.

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Presenter: This paper is presented by Trust Kashora

Appendix A

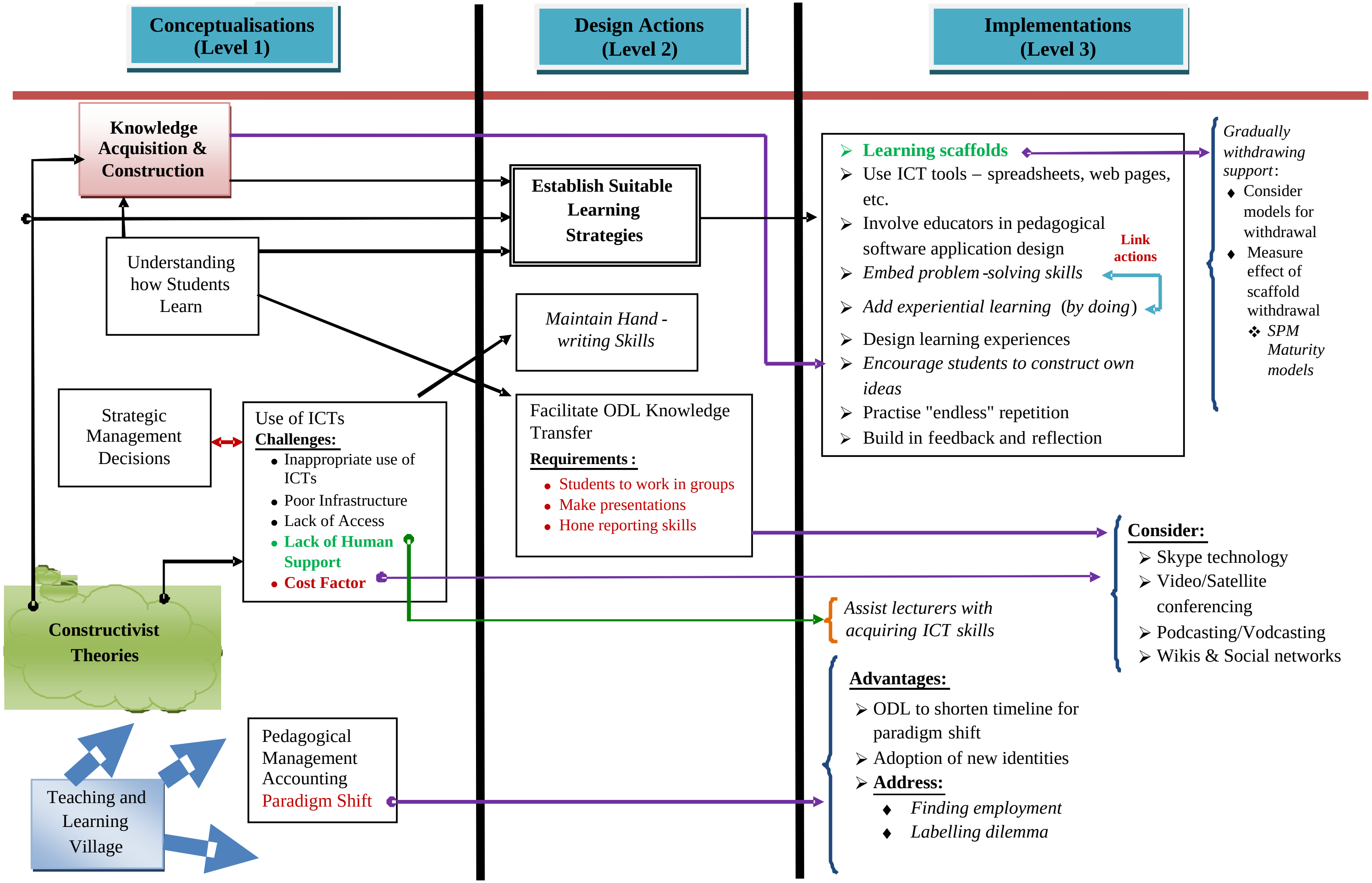

Figure 3: Knowledge Acquisition and Construction Framework

Low Voltage and High current Rectifiers Using AC Magnetic Link: A Comparison of Main Topologies

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Abstract

Phase controlled rectifiers designed to feed large currents at low voltage loads usually include a bulky step-down transformer. Furthermore, the need for large inductors to reduce the output current ripple limits the speed response of the system. To reduce the size of both, the transformer and the output inductor, it has been recommended to use multi stage rectifiers. Those rectifiers are composed by the cascade connection of a frequency changer, a high voltage transformer and a low voltage rectifier. Thus, it have limited current capability due to the lower current supported by high speed diodes when compared with standard diodes. A modular approach has been proposed to overcome this issue. These modular topologies are built through the connection of parallel modules, making a trade-off between current rating and simplicity. Teaching how to select the right topology for a given application is not a straightforward task. In order to help with converter design courses a comparison of critical characteristics of different topologies is necessary. This work shows a examples on different approaches of low voltage rectifiers comparing them in terms of number of semiconductor devices, types of input filter, speed and efficiency of the device, validating those theoretical considerations with simulations.

Keywords: *Low voltage, rectifiers, electroplating.*

1. Introduction

There are an important number of applications which require controlled power supplies in a range of thousands of amperes to feed loads operating at a few volts. For example, chargers for large capacity battery banks [1]-[8], electroplating processes [9]-[16], ballast water purifiers for ships between others [17]-[19]. In all these cases, efficiency and size of the equipment has been considered important topics for decision which has led to development of different topologies, each one with its own advantages and drawbacks.

The simplest topologies for this type of applications correspond to different phase controlled rectifiers connected to the secondary coils of a step-down transformer [20]-[25]. These topologies are very robust but require a bulky transformer. As a way to improve this, it has been proposed to locate the load current control unit in the primary side of the transformer. Then, there are systems which include an Alternating Current to Alternating Current (AC/AC) interface operating between the AC mains and the transformer, controlling the power flow towards the charge. If only energy efficiency improvement is required then this AC/AC interface will use Silicon Commuted Rectifiers (SCR) devices operating at the network frequency, so the transformer's secondary can be connected to a rectifier build with standard diodes [26]-[27]. Moreover, if as a requirement of the design it is necessary to reduce the size of the equipment, then, one of the options is to use a rectifier feeding to a Direct current to Direct Current (DC/DC) converter with a high frequency magnetic interface, that solution involves a reduction on efficiency due additional semiconductor connected in series at low voltage [28]-[34]. Finally, it has been proposed the use of topologies which permit to stack converters in parallel, improving the harmonic profile of the input current as well as the current capacity and its reliability through the use of redundant configurations[35]-[36].

An efficient way to include this topic in a power converter course for electric and electronics engineers or in a series of non specialized courses for mechatronics engineers is using a methodological approach to learning by problem resolution. Thus, the students are compelled to modelling and simulate different topologies to feed the same load. Using the simulated data, they need to compare them according to critical characteristics (i) amount of components, (ii) filter complexity, and (iii) efficiency. This work presents a comparison of different types of AC/DC rectifiers with a magnetic interface used in high current and low voltage. The comparison is done for a process of chromium electroplating operating at 6V and 1KA. Each section is presented with recommendation for professors and teaching assistant for better use. Finally results on use the material presented in this work and other similar guides covering different topics in integration workshops is presented and its results discussed.

2. Topologies

Several topologies are proposed for large current and low voltage applications. Choosing a suitable set for a course is important to clarify differences among the different rectifier families. The students must receive a formal introduction to each family and enough bibliography to start with modelling. In this work four standard topologies and two new proposals were chosen. The standard ones were: (a) the double bridge four stars rectifier, (b) the buck based chopper rectifier, (c) the AC main connected Load Commuted Converter (LCC) rectifier, and (d) the voltage source based multi stage rectifier with high frequency AC-Link (VSC-MSR). Additionally, two experimental topologies were included: (e) a modular multi-stage rectifier using a Pulse Width Modulation (PWM) voltage source frequency changers and (f) a modular multi-stage rectifier using PWM current source frequency changers. Topologies are shown below.

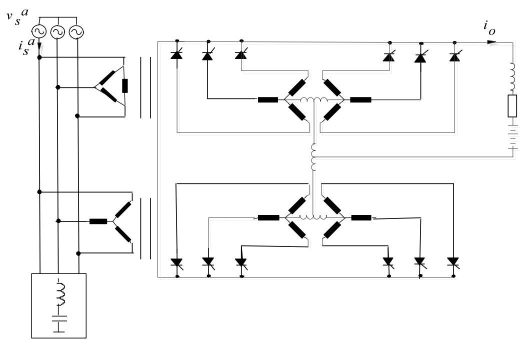

Figure 1. Double bridge four stars SCR based rectifier.

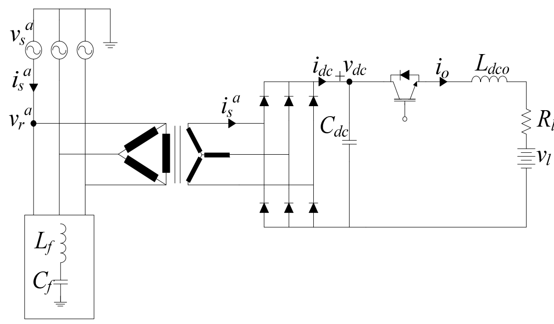

Figure 2. Buck based chopper rectifier.

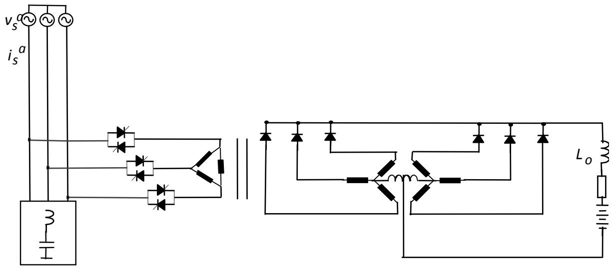

Figure 3. SCR load commuted converter (LCC) based Multi stage Rectifier.

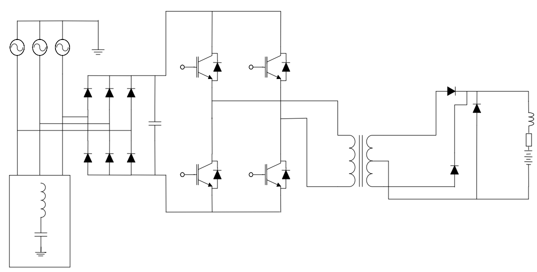

Figure 4. Voltage source based multi stage rectifier with high frequency AC-Link.

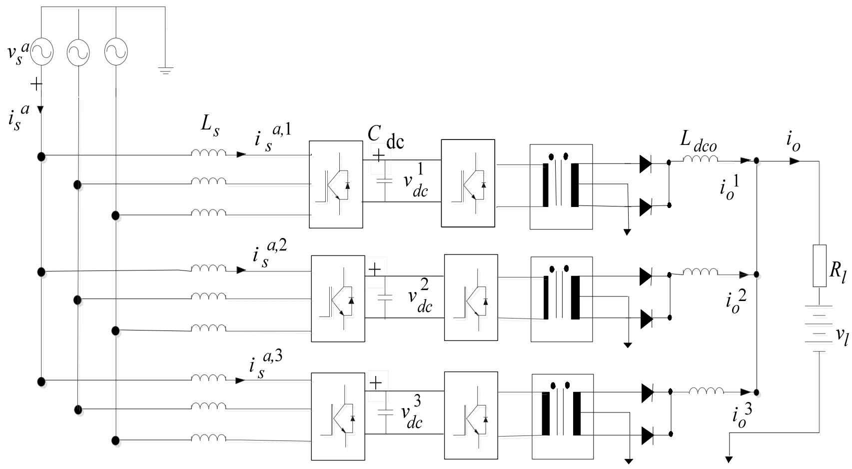

Figure 5. PWM voltage Source based topology proposed for modular Magnetic Coupled Converter with *P*=3.

The double bridge four stars rectifier (Figure 1) is one of the preferred phase controlled topologies used in the range of thousand amperes at low voltage. This because its single way structure reduce conductive losses as well as provides a 12 pulse current profile, avoiding the need for 5th and 7th tuned harmonic filters. The main drawback is the inherent reactive injection due the nature of the rectifier. Other popular topologies are the chopper Rectifiers. One of the simplest is the buck based chopper rectifier (

Figure *2*). The buck converter operating near 1 kHz permits an important reduction in size of output DC choke. Subsequently it improves the dynamic response. The main drawback for this topology is the reduced efficiency due the serial connection of three devices at time. On the other side 6 pulse rectifier needs harmonic filters tuned at 5th, 7th, 11th and 13th harmonics. To reduce the losses using SCR devices, a load commuted converter (LCC) based multi stage rectifier (Figure 3) was proposed. That topology intends to provide an efficient and robust DC source for large currents delivered at low voltages combining the robustness and simplicity of phase controlled topologies, with the efficiency improvements of multi stage rectifiers. The main drawbacks for this topology are the needs for harmonic filters tuned at 5th, 7th, 11th and 13th harmonics; and the inherent reactive injection due the nature of the LCC converter.

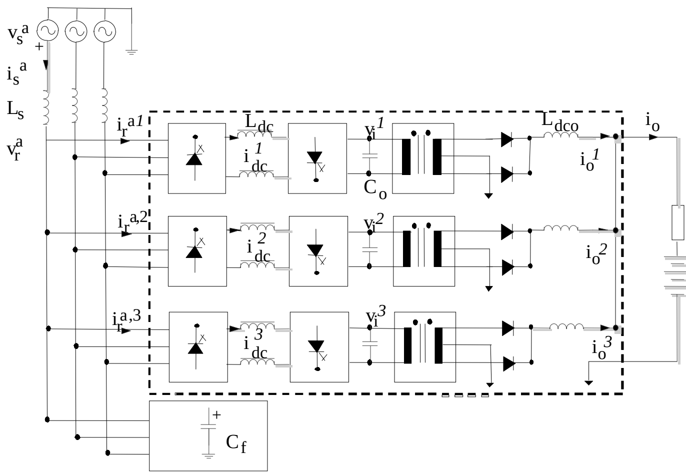

Figure 6. PWM current Source based topology proposed for modular Magnetic Coupled Converter with *P*=3.

In order to reduce size of rectifiers, several topologies include a high frequency magnetic link. Most are variations of voltage source based multi stage rectifiers. The basic topology is shown at Figure 4. It combines a simple front end composed by diode rectifiers, with an inverter switching at frequencies of several kHz. That solution reduces the size of the transformers and output DC choke. Thus, it results in an improved output dynamic. The main drawback of this topology is the reduced current capability due the use of high speed rectifier diodes at the low voltage rectifier. Furthermore, harmonic filters tuned at 5^{th}, 7^{th}, 11^{th} and 13^{th} harmonics are need. In order to overcome these drawbacks, a Modular multi-stage rectifier using PWM voltage source frequency changers (Figure 5) was developed. The intended features were (a) increasing the current capability of PWM based multistage converters and (b) for improving reliability in reference to a unique module. Thus, even if one module fails then the others rectifiers can still deliver the nominal output current (Figure 5). In a similar way, a multi-stage rectifier using PWM current source based frequency changers were proposed (Figure 6). This topology was developed for (a) increasing the current capability, (b) using simpler controllers than the VSI counterparts.

3. Simulations

Simulations have a big importance in power converter design. Students will be asked to perform simulations on circuit oriented tools like PSIM® or model oriented tools like Matlab®. In both cases it is important to compare student’s results with a previous simulated dataset or with experimental results. It is important to remark to students which quantities are important to compare. For this work, the important quantities are efficiency, number of valves, filter size, and dynamic response.

Table I. Simulation parameters

Parameter	Value
Common Parameters	
Supply phase voltage root mean square (*rms*)	220V
Supply frequency	50Hz
Output current	1000A
Output voltage	6V
Output resistance	1 mOhm
Tuned filters	
Input filter 5^{th} harmonic, capacitor	46 uF
Input filter 5^{th} harmonic, inductor	8.5mH
Input filter 7^{th} harmonic, capacitor	46 uF
Input filter 7^{th} harmonic, inductor	4.4mH
Input filter 11^{th} harmonic, capacitor	46 uF
Input filter 11^{th} harmonic, inductor	1.82mH
Input filter 13^{th} harmonic, capacitor	46 uF
Input filter 13^{th} harmonic, inductor	1.3mH
Input filters for PWM rectifiers	
First order filter, inductor	12 mH
Second order filter, inductor.	12 mH
Second order filter, capacitor.	42uF
Output Chokes	
Output Choke used for low frequency AC coupled rectifiers (300 Hz ripple)	1mH
Output Choke used for high frequency AC link coupled rectifiers (10kHz)	10uH
DC link	100uF
DC link capacitor for VSI based multi stage rectifier.	
DC link capacitors for PWM modular VSI based multi stage rectifier	30uF
DC link inductors for PWM modular CSI based multi stage rectifier	30mH
Switching frequency	
Chopper rectifier	1kHz
PWM VSI using square signal.	10kHz
PWM VSR using HI-PWM modulation.	10kHz
PWM CSI using square signal	10kHz
PWM CSR using DSHE multilevel modulation	350Hz on each module, equivalent to 1050 Hz on input current.

Summarized results taken for PSIM simulations are shown in Table II.

Table II. Performance indexes.

Converter	h	N° Valves	Input Filter Type	Dynamic Response
Four Star SCR based Rectifier	0,80	12	Tuned 11th-13th harmonics	250ms
Chopper Rectifier	0,58	7	Tuned 5th-7th-11th-13th harmonics	150ms
SCR-LLC based multi stage rectifier	0,85	12	Tuned 5th-7th-11th-13th harmonics	500ms
VSI based multi stage rectifier	0,79	12	Tuned 5th-7th-11th-13th harmonics	70ms
PWM modular VSI based multi stage rectifier	0,82	20	First order filter	120ms
PWM modular CSI based multi stage rectifier	0,80	38	Second order filter	200ms

Simulations are shown below.

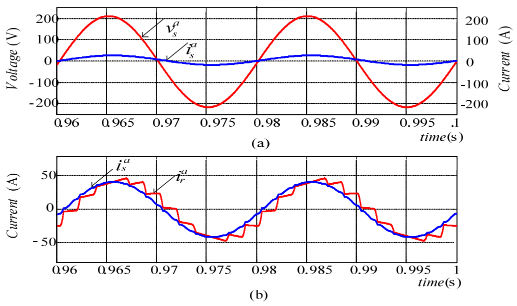

Figure 7. Double bridge four stars SCR based rectifier. (a) RMS input voltage v_s^a and RMS input filtered current i_s^a (b) input filtered current i_s^a and input unfiltered current i_r^a

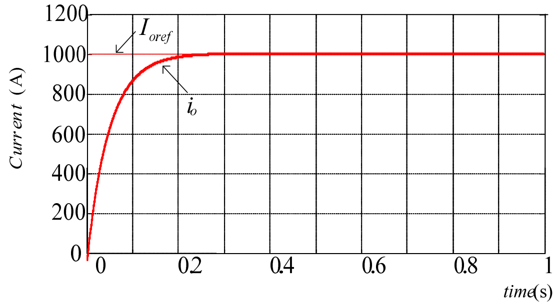

Figure 8. Double bridge four stars SCR based rectifier. Output current i_o and output current reference $I_{oref.}$

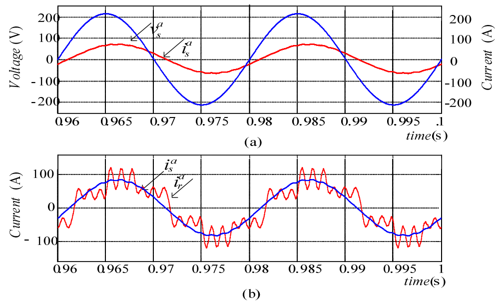

Figure 9. Chopper rectifier (a) RMS input voltage v_s^a and RMS input filtered current i_s^a (b) input filtered current i_s^a and input unfiltered current i_r^a.

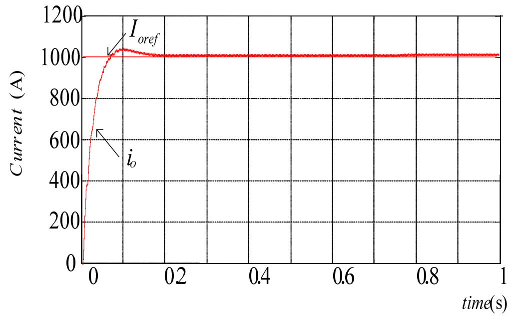

Figure 10. Chopper rectifier output current i_o and output current reference $I_{oref.}$

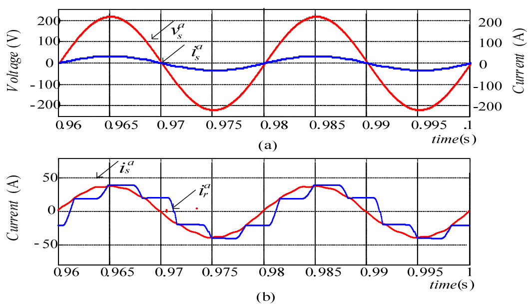

Figure 11. SCR load commuted converter (LCC)

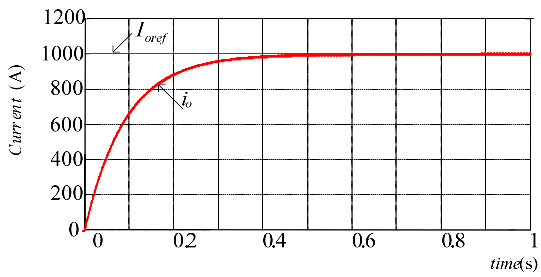

Figure 12. SCR load commuted converter (LCC)

based Multi stage Rectifier (a) RMS input voltage v_s^a and RMS input filtered current i_s^a (b) input filtered current i_s^a and input unfiltered current i_r^a.

based Multi stage Rectifier output current i_o and output current reference I_{oref}.

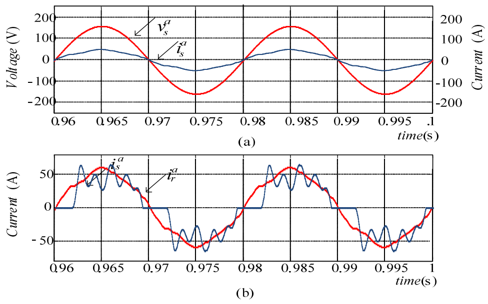

Figure 13. Voltage source based multi stage rectifier with high frequency AC-Link (a) RMS input voltage v_s^a and RMS input filtered current i_s^a (b) input filtered current i_s^a and input unfiltered current i_r^a.

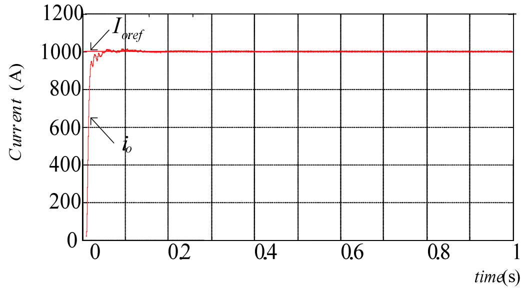

Figure 14. Voltage source based multi stage rectifier with high frequency AC-Link, output current i_o and output current reference I_{oref}.

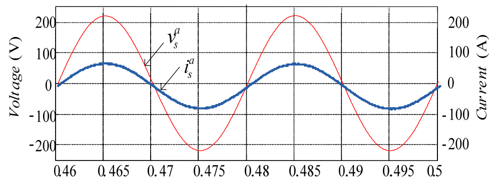

Figure 15. PWM voltage Source based topology proposed for modular Magnetic Coupled Converter with P=3, Input voltage v_s^a and input current i_s^a.

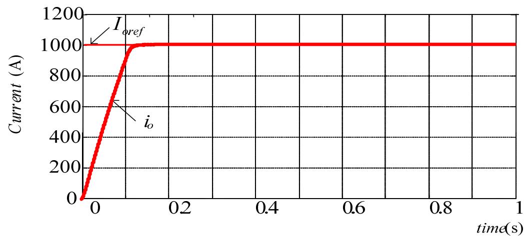

Figure 16. PWM voltage Source based topology proposed for modular Magnetic Coupled Converter with P=3, output current i_o and output current reference I_{oref}.

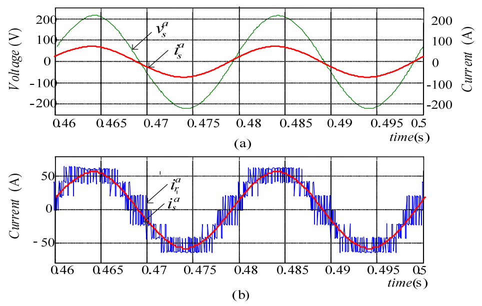

Figure 17, PWM current Source based topology proposed for modular Magnetic Coupled Converter with P=3. (a) RMS input voltage v_s^a and RMS input filtered current i_s^a (b) input filtered current i_s^a and input unfiltered current i_r^a..

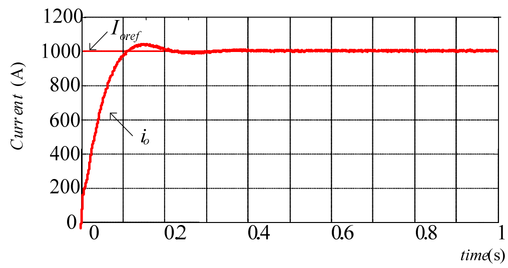

Figure 18, PWM current Source based topology proposed for modular Magnetic Coupled Converter with P=3. Output current i_o and output current reference I_{oref}.

Results shown that four stars rectifier show a 12 pulse input current pattern (Figure 7). It avoids the need for tuned filters to the 5th and 7th harmonics. However, tuned input filters to the 11th and 13th harmonics are still needed. Nevertheless, the low frequency operation results in large magnetic components with poor dynamics (Figure 8). The chopper rectifier presents a six pulse input current pattern (Figure 9). Thus, a large filter for the 5th, 7th, 11th and 13th harmonics must be provided. On the other hand, PWM output permits a size reduction in output filter, improving dynamic response (Figure 10). The LCC based Multi stage Rectifier, also presents a six pulse input current signal. It needs large tuned input filters to suppress the 5th , 7th , 11th and 13th harmonics (Figure 11). Additionally, large magnetic components make the dynamic response of this topology slow (Figure *12*). The voltage source based multi stage rectifier, presents a distorted input current requiring large tuned input filters for the 5th, 7th, 11th and 13th harmonics (Figure 13). Additionally, as the inverter operates at frequencies over 1kHz, there is a significant reduction in size and weight of the transformer and output filter inductance, resulting in an improvement in the output dynamic responses (Figure 14). The PWM voltage Source based topology use an active front end. It permits both (a) the reduction in size of input filter and (b) the operation at unitary power factor displacement (UPFD) (Figure 15). As well as in the previous topology described, the use of a frequency over 1kHz, permits significant reductions in the size and weight of magnetic components, resulting in better dynamics than the SCR-based counterparts(Figure 14). Finally, the modular PWM current Source based topology also use an active front permits both (a) the reduction in size of the input filter and (b) the operation of a unitary power factor displacement (UPFD) (Figure 15). In addition, the high frequency of the inverter output allows the reductions in size and weight of transformer and inductors. Thus, dynamics are better compared with SCR-based topologies (Figure 14). It is important to note that in general simplest topologies needs larger filters that results on slow dynamics in opposition to complex topologies, that needs shorter filter and have faster responses. Additionally, it is possible to reach efficiency over 80% in low speed topologies that use only one SCR at the load side of transformer and 85% in case of the LCC with the SCR in the AC mains side. Furthermore, efficiency over 80% it’s reached in modular topologies that split the output current in fraction reducing the drop voltage on high current high speed diodes.

4. Discussion

In Chile, the mining industry stills the main source of jobs for electric, electronic and mechatronics engineers. In the specific case of mechatronics students, design or maintain machines for traction and electrochemical process are an important part of the job. This is why power electronics is part of the knowledge given to these students. On the other hand, they have not the specialized courses of electrical engineers. That’s why a quick but effective way to train students is necessary. A proposed solution was introducing the topic in a general course of industrial electronic and then using a problem resolution strategy in a series of posterior courses. This method is compatible with the educative model based on competence. The curricula for mechatronic engineers at Talca University comprehend two years of basic sciences, two of engineering sciences and one of professional courses. Furthermore, to reinforcing the student advance in all their areas of knowledge the concept of integration workshops appears. They are consecutive courses placed in the terms 7th, 8th and 9th plus a final work at the 10th term. The first of these workshops evaluates the capability to model and simulate (a) electro-mechanic process, (b) electrochemical process and (c) thermal process. In the second workshop a machine needs to be designed for the student. In the third workshop the design has to be built. Finally in the final work to obtain the professional title the machine must be controlled and the student must defend his work in front of a commission of professors. In the first workshop described previously students use the knowledge on power converters to model and simulate machines, thermal process or chemical process feed by rectifiers or inverters. They are organized in groups, each one with the task to model and simulate a set of systems in the term. They have the help of teaching assistant that have the full version of the guides and the student guides presenting results for a set of parameters different to the ones to be solved, without the observations or conclusions. Then, they can use the data in the guides to check the quality of their models. Finally students must compare each approach, send a report, and share results with the rest of the class. Main difference in the course before and after of use that approach are (a) reduction in time to finishing each individual project from 6 weeks to 4 weeks, saving time to include more topics, (b) help the students to see the big picture when start to modelling a system and (c) improve the holistic vision of students by using knowledge covered by different courses to solve an specific problem.

5. Conclusion

This work presents a guide used to help to teach a specific topic in both, specialized and general courses. It compares several topologies used to feed low voltage loads in a typical sample of electroplating process developed at 6V/1KA, providing a guide on how to teaching this topic in power converter courses. Theoretical models were presented and simulated results were used to compare different types of low voltage rectifiers. Finally a discussion on how to use the material in general courses is presented, mentioning the improvement in time to finish projects and the capacity of students to see separates knowledge as part of a whole system.

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Technology-moderated Training Approaches

Modelling as an Element of Design Thinking in U.S. Secondary Schools

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Abstract

This research exposed the cognitive thought processes employed by high school students as they practice engineering design thinking. Results show that students spent little time in the problem scoping stage. Information gathering was primarily related to the solution rather than understanding the problem. Student brainstorming sessions were short, infrequent and seldom provided alternative designs. Brainstorming typically resulted in added elements to the design rather than providing the opportunity to evaluate and make decisions on different solutions. Students spent significant amounts of time modelling and communicating. Modelling was the overwhelming bias toward graphical rather than mathematical or physical representations.

High school students engage in design thinking with little understanding of the problem from the client's perspective and move quickly to developing a solution. Students become fixated on a single solution and adding to the solution rather than comparing alternative solutions. Few students considered location, use, users, clients, goals or objectives of the stakeholders in their design process. High school students after four or five engineering related courses, seniors in high school, many of whom plan on pursuing engineering, do little or no mathematical modelling.

Keywords: *Engineering Design, High School, Engineering Education, Modelling Behaviours, Technological Literacy*

1. Introduction

The engineering design process is a systematic problem solving method and is an essential element of the field of engineering. "The key to educating students to thrive in a competitive global economy is introducing them early to the engineering design skills and concepts that engage them in applying their math and science knowledge to solve real problems"[1]. Today, Science, Technology, Engineering, and Mathematics (STEM) education continues to be a national concern in the United States and technology and engineering education (the 'T' and 'E' of STEM) have seen increased attention in recent years. The National Academy of Engineering commissioned a study titled "Engineering in K12 Education" which included a review of U.S. curriculum materials related to the T and E of STEM education as well as the relationship between Science, Technology, Engineering and Mathematics education. The National Academy's work emphasized the role of engineering in improving STEM education as it may be a "catalyst" serving to draw connections between mathematics, science and technology education and engineering design has the potential to integrate science, technology and mathematics concepts for students [2].

This paper discusses the results of a National Science Foundation funded project focused on understanding how high school students think through the engineering design process. Results and analysis compare high school students to practicing expert engineers in terms of engineering design performance and knowledge.

Analysis of the design thinking data showed that when comparing high school students to expert engineers, students exhibited certain deficiencies in the design process including: *problem definition, information gathering, brainstorming, decision making, mathematical modelling and analysis, design development, and communication*. Each of these deficiencies in design represents an opportunity to improve education at the secondary level.

While this research uncovered evidence that high school engineering and technology students are modelling [3 - 5], the National Academy of Engineering Committee on K-12 Engineering Education [2] found that very few curricula or professional development initiatives use mathematics in ways that support modelling and analysis. In addition, Dym and Little [6] suggested that modelling in the context of engineering is a representation in mathematical terms. Since modelling accounted for approximately 60% of student design time it will be the focus of this paper. The conflict between student engagement in modelling, as reported by the research, and the lack of a formalized curricular focus on modelling is discussed.

2. Background

Design is essential to the disciplines of engineering and technology. Atman Cardella, Turns, & Adams [7] stated that "design is a central activity to all types of engineering. Mechanical, civil and electrical engineers attempt to solve very different types of problems, but they all design some solution to the problem at hand". Sheppard, Macatangay, Colby, and Sullivan [8] stated that "engineering design involves a way of thinking that is increasingly referred to as design thinking: a high level of creativity and mental discipline as the engineer tries to discover the heart of the problem and explore beyond the solutions at easy reach".

Design thinking is fundamental to understanding the technologically dependent nature of our society. It is this design process which connects technology and engineering, two elements of STEM education. "Design is the central component of the practice of engineering and a key element in technology education" [9]. Design thinking is a creative way of problem-solving [10]. It promotes developments of diverse ideas, which are essential for innovation [11]. Studies show that teaching design thinking helped students in learning core subjects as well as fostering social skills [12, 13]. In addition, it encourages students' metacognition [14].

The Center for Engineering Learning and Teaching at the University of Washington (UW) has provided substantial insight into the design thinking and performance of college students and experts, as well as, provided comparisons on a variety of constructs [15 - 19]. Implications of this work provide guidance for collegiate learning and teaching environments. The goal of the research extends the continuum of novice to expert to include high school learners. By leveraging the Washington based Center's work on experts as a trajectory for high school student development, this research project has implications for high school curriculum development, learning, and teaching methodologies. Design problems in these previous studies were ill-structured and open-ended. These kinds of problems have many potential solution paths stemming from an ambiguous identification of a need. Engineering design problems in practice tend to be structurally open-ended and highly complex. An open-ended problem may have numerous solution paths and be bound by some rigid and some negotiable constraints, not always presented with the problem. Through the lens of an ethnographer, Bucciarelli described engineering as a social process [20]. The processes employed in engineering design encompass a broad variety of topics and fields of study. The National Academy of Engineering suggested that engineering education was deficient if it did not include the global perspective in engineering design such as social, political, and environmental issues [25, 26]. The global perspective of engineering is synonymous with the term "systems engineering." Systems engineering involves design from the whole systems level rather than from an isolated modular perspective.

Not only do open-ended problems more accurately reflect industry practices, they also provide students more flexibility and choice [21]. As students are given more freedom and choice, they become further engaged in their own education [22, 23]. As such, open-ended problems give the student an authentic experience and greater motivation [24]. The design activity used in this research does not require domain-specific knowledge such as electrical or mechanical engineering and, therefore, is accessible to many student participants with a variety of backgrounds and experiences [18].

3. Data Collection Methods

This research used triangulation mixed methods research strategies (quantitative and qualitative data were collected and analyzed concurrently) providing multiple lenses from which to understand engineering design thinking among high school students. Areas of congruence between quantitative and qualitative data enable strong conclusions regarding design thinking, while points of divergence highlight gaps in student learning between “design knowledge and its practical application” [16].

Participants were given a one page design problem assigned to design a playground on a donated city block. The constraints included limited budget, child safety, and compliance with laws or zoning. The participant was also able to query the research administrator for additional specific information such as, the lot layout, cost of materials, or neighbourhood demographics. There was a three-hour time limit for completion of the design proposal. The participants were asked to generate a written proposal describing their design. This activity engaged the participants in problem framing and developing an initial solution. Limitations of this design task included the lack of opportunity for participants to investigate the need for a solution. It was directly presented to them. Students did not have an opportunity to construct physical models or prototypes and participants were aware that implementation of the design project would not occur, and their designs would not become realized.

Video recorders were used to capture the student’s design thinking and were placed to create a view of the students working as well as to capture the table the students were working on. The documents used in administering the problem were coloured to help the researchers differentiate between information. Additional specific information asked for by the participant was (blue), problem definition (yellow) and student work (white).

Three hours were allotted for students to complete the design task, although the average student completed the problem prior to the administrator stopping the session. During the participant’s design session, a member of the research team acted as the administrator of the problem. The administrator provided the students with a physical copy of the design task and read it aloud with them (for more details on the design task refer to Atman [15, 16]). The design task included a description of the general constraints and the method students could use to access information. The administrator provided various documents containing information upon specific request. While students were working, the administrator kept track of the information requested by the students. Using a simple chart, the administrator made a note of what information was requested by the participant, as well as the specific time the information was requested.

During the design task, the administrator was responsible for ensuring participants were continually thinking aloud. It was imperative for the participant to verbalize their thoughts while simultaneously working through the problem. This was done by the administrator prompting the students with reminder questions, such as, “keep talking”, “what are you thinking”, “what are you doing”, “what are you drawing”. The administrator also created a list of questions that were focused on the participant’s solution development to be used for a follow up interview that was conducted afterwards within a few weeks of data collection. These served as a way for the research team to gain more information about what students were doing while developing their solution. Common questions asked of participants were, how did you define the problem, how did you compare ideas, why and how did you choose your final idea or plan, along with questions directly related to the students work. When the follow up interviews were completed, students were compensated for their time.

4. Data Analysis

The design problem coding scheme was congruent with the approach used in prior studies [15, 17, 18]. The data were coded into nine categories presented by Mosborg et al., [18]: **Problem Definition (PD)**: Defining what the problem really is. **Gather Information (GATH)**: Searching for and collecting information needed to solve the problem. **Generating Ideas (GEN)**: Thinking up potential solutions (or parts of potential solution) to the problem. **Modelling (MOD)**: Detailing how to build the solution (or parts of the solution) to the problem. **Feasibility Analysis (FEAS):** Assessing and passing judgment on a possible or planned solution to the problem. **Evaluation (EVAL)**: Comparing and contrasting two (or more) solutions to the problem on a particular dimension (or set of dimensions) such as strength or cost. **Decision (DEC)**: Selecting one idea or solution to the problem (or parts of the problem) from among those considered. **Communication (COM)**: The participants' communicating elements of the design in writing, or with oral reports, to parties such as contractors and the community. **Other**: None of the above codes apply.

Data analysis began with segmenting the data sets. Two graduate students segmenting the data. Each was assigned one-half of the data set. To ensure quality segmenting, each graduate student segmented one fourth of a video assigned to the other student. This provided 25% overlap based on video time. Segments generated by each graduate student were assembled into a spreadsheet and compared. The research leadership team qualitatively reviewed the discrepancies and coached the graduate students toward consensus. This process was iterative as the students would segment one video, meet, resolve differences and segment the next video. Quantitative measures of inter-rater reliability on segmenting were not made. The research leadership team determined whether or not the segmenting of reasonable quality by the inter-rater reliability measures for coding was high. If segmenting was done successfully, coding could potentially result in high inter-rater reliability. Coding served as a proxy for quality control of the segmenting process.

Two undergraduate students coded the data. The coders were also assigned one-half of the data set each. The undergraduate coders used the segmented data and each coded 25% of the other student's assignment for a total overlap of 25% measured by time. The students generated a Kappa value for each code based on the coding comparison tool in NVIVO 8 software. Coders, under the guidance of project leadership, began to resolve discrepancies prioritizing the lowest Kappa value codes and working toward agreement. At the conclusion of the discussion, the team would document their negotiations (learning from their mistakes) in a dynamic coding document and attempt 25% of the next video. This iterative process continued throughout the data set. When 25% of each video was coded, the coders began to code full videos, redoing the early comparisons with low Kappa values. Kappa values are reported as an average of all 59 comparisons done independently.

A "Dynamic" Code Book was created and maintained. This was a document with very specific examples of the different codes developed by creating a description of the code and compilation examples in context. This included adding detail and clarifying the meaning of our segmenting and coding procedures and providing examples as coders did their work. The document was updated regularly and shared via network real time. The codebook was a 'living document' with the intent that it would grow in details as the project developed. As understanding and interpretation was negotiated by the segmenters, coders and research team leaders, the codebook documents the increasingly specific definitions. Any team member could update the code book. Skype provided access for distance desktop and video media sharing by the team as they spanned three geographic locations.

Two undergraduate students were trained in the coding methodology using documents shared by the University of Washington. While the coding scheme was consistent with previous literature, the technique was slightly different. Previous work used transcriptions, segmenting and coding as three separate activities in the analysis process [15]. Inter-rater reliability was calculated on the coding to ensure reliability of the multiple coding analysts. This project bypassed transcription using NVIVO software which presented coding analysts with synchronized video and audio feed. Codes were associated with the timeline on the video/audio tracks and inter-rater reliability was computed with Cohen's Kappa statistics. Inter-rater reliability data is presented for each code in table 1 along with the number of coded references for each code. The number of references includes the coding of both undergraduates and serves as a sum of the two students. The average inter-rater reliability of 0.91 was higher than the comparable previous work [27]. A total of 11,162 segments were coded for comparison representing 25% of the total data set among the 59 participants.

Table 1. Cohen's Kappa for each design activity.

Design Activity	Cohen's Kappa	References
Problem Definition activity	0.9087	730
Gathering Information activity	0.9497	1551
Generating Ideas Activity	0.8959	408
Modelling activity	0.9186	6512
Feasibility Analysis activity	0.7978	914
Evaluation activity	0.9238	49
Decision activity	0.9192	103
Communication activity	0.9427	895
Average Inter-Rater Reliability	**0.90705**	

4.1 Sample

Four schools were identified and recruited for this study representing four US states, and range from urban to rural. Thirty students were recruited who had completed courses in the engineering sequence at the high school. Typically, these were senior students, but some students took all the courses prior to their senior year. Thirty students were chosen, typically freshmen, if they had intentions on completing the sequence of engineering courses and were in the first course. This sample permitted conclusions about differences between program starters and program finishers, referred to here as freshmen and seniors. Student demographic data are shown in table 2.

Table 2. Participant demographics and number of Male and Female participants.

	Number of Participants	
Self reported identity	Male	Female
Asian	2	1
Black or African American	12	0
Hispanic or Latino	2	3
White	25	7
More than One Race	4	2
Other or Unknown	2	0

5. Results of Research

Comparison between novice high school students and experts engineers suggests substantial differences. Table 3 provides the average time and standard deviation represented by minutes spent and the percentage of total time. Expert data are presented from Atman [27] for comparison. Atman identified eight elements of the design process grouped into three stages. We choose to display "other" which represents time in the design process not coded in the other eight elements.

High school students tackled the design challenge without hesitation. Fifty-nine students participated in this study, 30 of whom were finishing their sequence of engineering courses and 29 were beginning the sequence. Students spent an average of 92 minutes engaged in the design challenge as compared to 132 minutes for experts. Table 4 compares high school freshmen and seniors by gender.

Table 3. Mean and standard deviation summary statistics for high school students and experts.

Design Process Measures	High School Students (n=59)		Experts (n=19)	
	Minutes (SD)	Percent of time (SD)	Minutes (SD)	Percent of time (SD)
Total Time	91.7 (47.4)		131.9 (20.3)	
Problem Scoping stage	15.5	18.0	31.3 (16.2)	24.4 (12.5)
Problem Definition	5.6 (3.1)	7.7(4.9)	8.3 (2.8)	6.3 (2.0)
Gathering Information	9.9 (13.3)	10.3(11.7)	23.0 (16.3)	18.0 (12.5)
Developing Alternative Solutions stage	63.2	70.5	93.3 (25.3)	70.2 (12.1)
Generating Ideas	2.9(6.6)	3.9(10.5)	6.6 (5.8)	5.0 (4.5)
Modelling	54.4 (35.4)	60.2 (17.4)	73.2 (24.6)	55.1 (13.6)
Feasibility Analysis	4.4 (4.1)	5.4 (4.5)	11.6 (6.5)	8.8 (4.4)
Evaluation	1.1 (3.5)	1.0 (3.0)	1.9 (2.3)	1.4 (1.7)
Project Realization stage	8.2	7.6	7.3 (5.4)	5.5 (3.7)
Decision	0.4 (0.7)	0.4 (0.6)	2.4 (1.8)	1.8 (1.2)
Communication	7.8 (13.0)	7.2 (11.1)	4.9 (5. 0)	3.7 (3.5)
Other	3.1	3.8	0.0	0.0

Results indicate that students spent less time in the problem scoping stage than did experts. This was evident in the quantitative data, also on a qualitative level. High school students averaged 5.6 minutes considering the problem while experts spent 8.3 minutes. *Information Gathering* code applied when students were looking for information about their design problem or solution. Students spent less than half the amount of time in the *Information Gathering* phase compared to experts. Students were able to query the research administrator with specific questions to probe for information, which is consistent with previous literature. Generating ideas was coded when students were developing possible ideas for a solution, brainstorming, or listing different alternatives. High school students in this study rarely followed a “textbook” approach to brainstorming. This classic step in the design process is characterized by creating a list of possibilities without passing judgment. All judgment should be suspended during brainstorming so that wild ideas may spark another related, but practical idea. Students in the study rarely conducted this form of brainstorming. Rather, they recalled their previous experiences and frequently stuck with the first thoughts that came to mind. Students spent less than three minutes engaged in brainstorming as compared to experts’ average of 6.6 minutes.

Students and experts spent a good deal of time modelling. Efforts to model included determining size, position, scale, quantity needed, shape, and location. Modelling was done visually (described verbally), graphically, physically and through mathematical representations. Students spent less time than did experts modelling, but did spend a higher percentage of time in this area. Students spent very little time determining the feasibility of their ideas and little time evaluating alternative designs. Feasibility was coded when students attempted to determine if a solution was viable and practical. In the *Evaluation* activity, the research team looked for students to compare alternatives and make judgments. When students did compare alternatives, they did so in a very clear overt way. Interestingly, all comparisons (though there were very few) were done verbally. None of the students created a decision matrix or anything that even resembled a matrix to compare alternatives. For the senior students, all having taken a capstone course, it seemed reasonable to assume they would spend more time making decisions and have a systematic method for comparing alternatives. This was not the case.

Students spent very little time in the decision making process. They frequently took the first idea that came to mind and implemented that in their design. They seldom compared alternative solutions in evaluation and made very few decisions. Decisions were coded when students specifically choose between two or more alternatives. In many cases, a student would specify some element of their design without considering alternatives. As an example, typically students would include a swing set in their design and may specify a colour, material, height and other details. This was not a coded decision unless they were considering two or more alternatives. With students' habits of implementing the first idea that comes to mind, few decisions were made.

Table 4. Mean and standard deviation summary statistics for high school students.

Design Process Measures	**Freshmen High School Students** Minutes (SD)		**Senior High School Students** Minutes (SD)	
	Females (n=6)	Males (n=24)	Females (n=7)	Males (n=23)
Total Time	111.0 (51.8)	89.9 (45.3)	57.6 (47.6)	100.0 (45.8)
Problem Scoping stage	22.2	16.3	9.9	14.6
Problem Definition	5.0 (2.8)	5.5 (2.6)	3.5 (1.1)	6.5 (3.7)
Gathering Information	17.2 (15.7)	10.8 (15.0)	6.5 (8.4)	8.0 (12.1)
Developing Alternative Solutions stage	70.1	61.1	40.6	69.6
Generating Ideas	1.1(1.6)	1.4(2.2)	8.3 (18.4)	3.2 (2.5)
Modelling	66.0 (46.4)	55.2 (35.3)	30.0 (32.2)	58.0 (32.4)
Feasibility Analysis	2.8 (2.0)	3.7 (3.5)	2.1 (1.5)	6.3 (5.0)
Evaluation	0.1 (0.2)	0.7 (2.0)	0.2 (0.4)	2.1 (5.2)
Project Realization stage	15.6	3.4	7.3	11.5
Decision	0.0 (0.0)	0.1 (0.3)	0.2 (0.3)	0.7 (0.9)
Communication	15.6 (15.4)	3.3 (7.2)	5.6 (10.4)	10.8 (16.0)
Other	2.0	3.0	1.1	4.1

Students spent more time than did experts in communication. Communication was coded when students made explicit reference to documenting their design so that it could be built or they provided evidence that the documentation was for someone else. Evidence included attempts to scale the drawing, annotations, detailed drawings, and use of rulers and straight lines. The difference between developing their idea (modelling) and documenting their idea (communication) was difficult to distinguish in practice. This difficulty may be related to students thinking graphically and using drawing as a mental tool to represent data which they discover is incomplete when shown on paper. This incomplete representation of the design is developed further on paper, and eventually becomes their final design. Modelling is discussed further in Mentzer and Huffman [4].

Data suggested that high school students spent more time in the project realization phase, while experts spent considerable time in problem scoping and developing alternative solutions. Figure 1 graphically represents the average time in each phase. Figure 2 provides graphical representation breaking each stage into an element of the design process. This detail suggested that experts spent nearly twice the amount of time gathering information as did students. Experts were substantially more involved with modelling, feasibility, and evaluation than were high school students. High school students spent much time communicating their results, though researchers noticed their documentation was generally of very poor quality. Quality was not objectively measured in this study, but without exception, the research team agreed that a contractor would <u>not</u> be able to build the playground from the design documentation as presented. In most cases, the documents were very disorganized, messy, and incomplete.

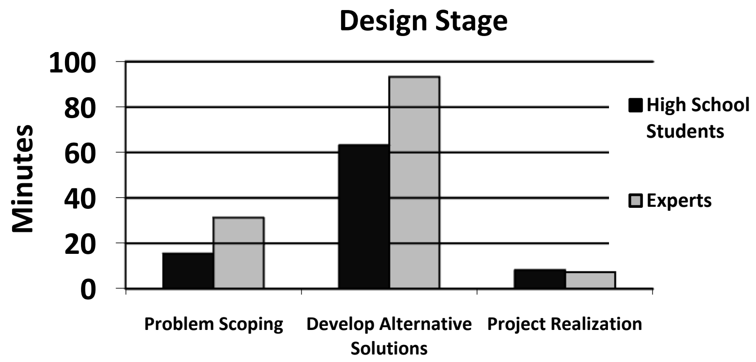

Figure 1. Mean time expressed in minutes each group spent in playground design stages.

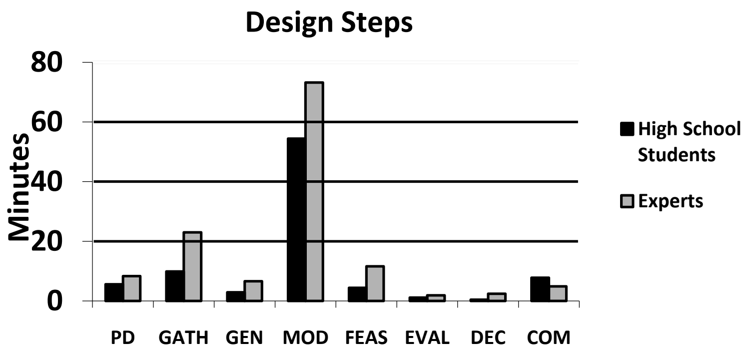

Figure 2. Average time spent in each design step for high school students and experts.

Gender differences were noticed across the student groups (refer to Table 4). Freshmen spent more time than did seniors on the problem while freshmen females and senior males spent more time than their counterparts. Freshmen females spent more time gathering information (17 minutes) than did freshmen males and seniors (11, 7 and 8 minutes). Senior females spent a considerable amount of time generating ideas as compared to the other groups (8 minutes as compared to 1, 1 and 3 minutes). Senior females modelled much less than did senior males and freshmen with 30 minutes as compared to 58, 55 and 66 minutes. Female freshmen spent more time communicating and no time making decisions as compared to their counterparts.

Data suggested that high school freshmen spent more time in the project realization phase, problem scoping and developing alternative solutions. Figures 3 and 4 provide graphical representation breaking each stage into an element of the design process. This detail suggests that experts spent much more time gathering information as did students. Experts were substantially more involved with modelling, feasibility, and evaluation than were high school students. High school students spent much time communicating their results, though researchers noticed their documentation was generally of very poor quality.

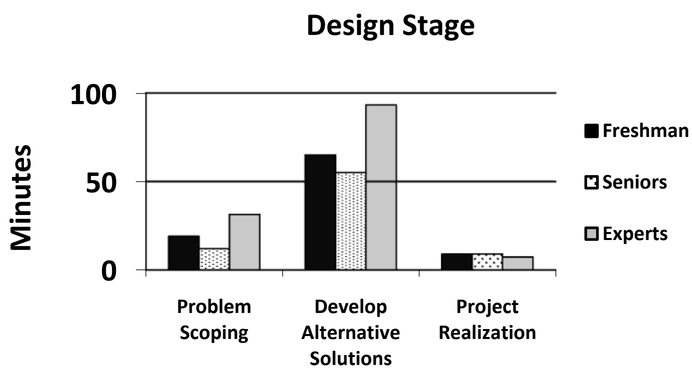

Figure 3. Mean time expressed in minutes each group spent in playground design stages.

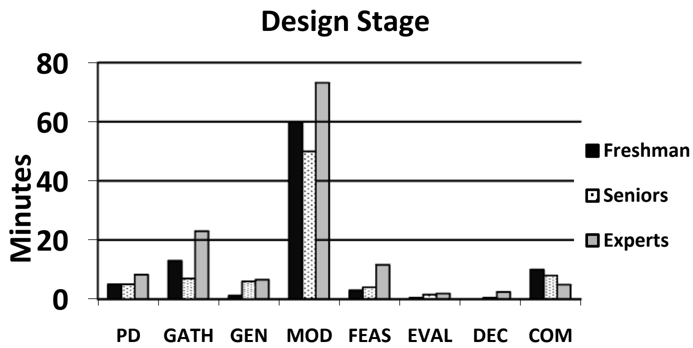

Figure 4. Average time spent in each design step for freshmen, senior, and experts.

5.1 Modeling

Students spent about 60% of their design time modelling. The sheer volume of time spent engaged in this activity caused the authors to investigate further. Most students in this study utilized various types of modelling, but the amount of time students spent was far from balanced. To illustrate this, three senior high school student cases related to modelling are discussed. Student #1 shows an extreme case of using mathematical modelling during design to drive decision making and provide explanation. Student #2 quantifies for purposes of description, but was unable or unwilling to utilize mathematical modelling to create relationships. Student #3 rarely used mathematical modelling and chose instead to engage almost exclusively in graphical modelling. While these three students offer a view of what the students are actually doing with regard to modelling, they are not necessarily representative of the entire sample. Overall, the majority of the participants fell somewhere between using only graphical modelling (Student #3) and using some mathematics for description purposes (Student #2). Few students created mathematical functions or relationships between variables in their design work. The inclusion of the student who uses mathematical modelling for explanation (Student #1) may present an exemplar high school "engineering" student as recognized by the literature.

Student Case #1 (study participant 1511): a student that used mathematical models to inform design decisions.

Before participating in the design challenge, Student #1 had taken four technology and engineering classes. She indicated that brainstorming, making decisions, identifying constraints, modelling, prototyping and testing were the most important factors to consider during design. Additionally, she indicated that the least important activities in the design process were abstracting, decomposing, evaluating, iterating, making trade-offs and visualizing. Student #1 spent over two and half hours engaging in the design activity. As shown in figure 5, Student #1 iterated between different elements of the design process, revisiting problem definition occasionally in the first half of her session. She spent a good deal of her time modelling, but gathering information was also an area where she allocated time. She worked on communicating her design so that it could be built primarily during the latter half of her session. Consistent with most students in the study, she spent a limited time considering the feasibility of her ideas and very little time evaluating alternative designs and making decisions. She engaged in one short brainstorming session early in the process and manipulated those few ideas for the duration of her work.

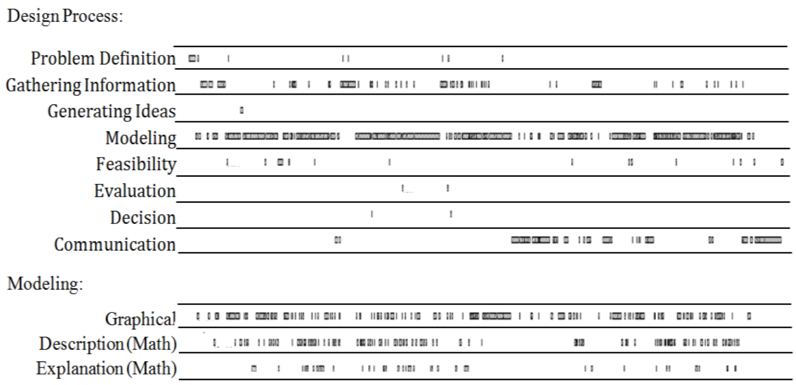

Figure 5. Timeline for Student #1 (study ID: 1511) showing design and details on type of modelling used.

Student #1's approach to modelling remained consistent through the design challenge which can be noticed by the general visual redundancy in the timeline (figure 5). Student #1 would quantify parts of the design component including size and cost of the bench, and continued to study how the addition of that design component would affect other parts of the design using mathematical expressions to describe and explain design decisions that she makes. For example, if the addition of the bench created less room for other design features, Student #1 would adjust the size of those design features accordingly. Student #1 kept a continuous mathematical model that represented two design constraints: playground area and cost. When she would change a variable by adding a playground activity, she inputted the new size and cost and calculated the new design feature's effect on the overall design parameters. Student #1 would then use the information gained to inform further design decisions.

Student #1's design documents consisted of four pages. Three pages documented specific playground features, the size and layout of each, cost and a bill of materials list. Additionally, these pages described how to construct the features based on particular measurements. Student #1 spent time calculating the appropriate sizes of her materials. As revealed in figure 6, Student #1 would utilize specific mathematical techniques such as the Pythagorean Theorem to guide her material cost and size constraints.

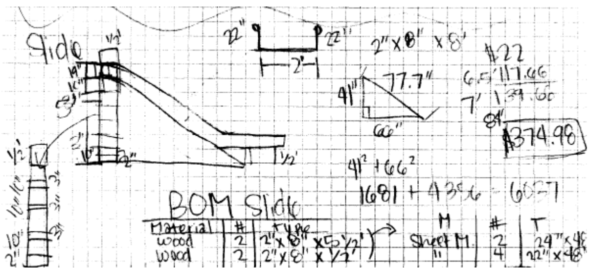

Figure 6. Student #1's slide building artefacts.

The fourth page contained a large area for the playground plan layout and second area as a key to describe specific parts of the playground.

Student #1 began modelling by stating that she was designing the second side of the monkey bars as a mirrored version of the first side. She placed the location of the bars (Graphical). Student #1 then requested prices for wood or lumber and related the monkey bars to a design constraint of “being cheap and made of materials available at the local hardware or lumber store” (Mathematical Description). After recording the price of the lumber, Student #1 considered what size lumber would be the most “stable”. Student #1 decided that 2” by 8” by 8’ piece of lumber would be a good place start and stated, “I’m going to try that size and see” (Mathematical Explanation). Student #1 graphically placed the lumber “to see how the lumber will fit best based on the size that [she] I choose” on her drawing (Graphical). Student #1 continually discussed how much material would be left over and when she may need to purchase a new piece of wood (Mathematical Description/Explanation). Student #1 next looked to optimize her system based on material cost and sizes. Student #1 decided to “redesign” the bottom step by changing the height from two feet to one and a half feet (Mathematical Description/Explanation). After this change, she identified a smaller piece of lumber for purchase. As indicated in figure 7, Student #1 realized that lumber cost could change depending on the number (#) of items purchased and the size (type).

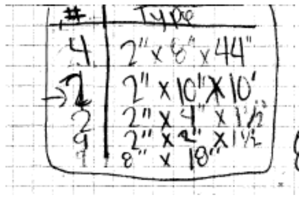

Figure 7. Student #1’s material decision table.

Student #1 elected to evaluate different sizes of stock lumber for her design. She repeated the process for five different limber sizes and selected one size based on cost effectiveness.

Student Case # 2 (study participant 3609): a student that used mathematical models to describe design features.

Student #2 is a senior high school student. Before participating in the design challenge, student #2 had taken five technology and engineering classes. Student #2 indicated that generating alternatives, making decisions, planning, seeking information, testing and understanding the problem were the most important factors to consider during design. Additionally, he indicated that the least important activities in the design process were abstracting, imagining, iterating, making trade-offs, sketching and using creativity. As shown in figure 8, Student #2 made iterations between elements in the design process and concentrated heavily in modelling during the first half of his session and communication during the second half. He revisited the problem multiple times and generated ideas on multiple occasions. He spent more time than most students engaging in feasibility to consider if the idea he was considering might work. He spent little time in evaluation and decision making.

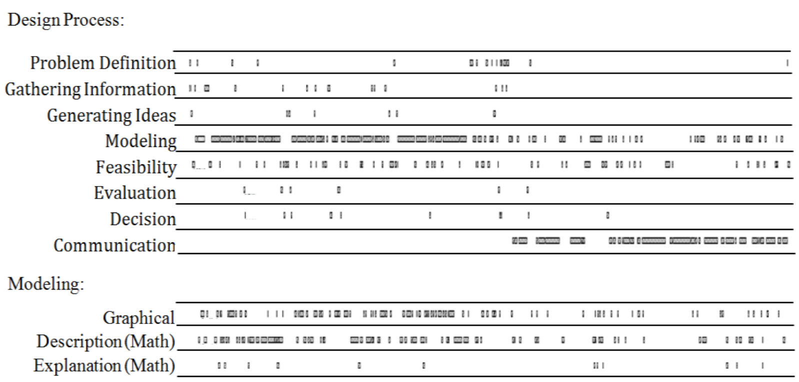

Figure 8. Timeline for Student #2 (study ID: 3609) showing design and details on type of modelling used.

Student #2 followed a regular pattern throughout the design challenge. Student #2 spent a great deal of time describing design features mathematically. He would draw a design feature, such as a tire swing, and then immediately quantify parts of the design (figure 9). While Student #2 would quantify, these quantifications would rarely (5% of his time modelling) lead to new design decisions. When Student #2 would attempt mathematical explanations, he often failed to execute certain mathematical equations. For example, Student #2 indicated that he knew there was a formula to calculate the slope of a right triangle, but failed to derive the Pythagorean Theorem. In this research, students were often able to transfer in some knowledge but not always the "right knowledge".

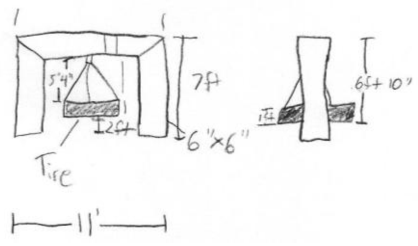

Figure 9. Student #2's quantification of design features.

Student #2 was able to transfer in some mathematical understanding about the situation however, he failed to transfer in the "right knowledge" in order to derive the mathematical equation. In contrast to Student #1, Student #2 utilized mathematics primarily to describe and not to inform decisions.

Student #2 generally repeated during the design session. He spent over 53% of his modelling time in mathematical description and began by deciding to build a set of monkey bars. He was primarily concerned with how the monkey bars' size related to the children that may be using it. He stated that he previously decided the monkey bars should be "eight feet off the ground" and made a rough sketch the design (Graphical). He continued to document the overall size of the monkey bars and platforms by adding dimensions and stating each measurement (Mathematical Description). He then evaluated if the selected size was appropriate for a "little" kid by stating "a kid four foot tall will not have a seven foot reach". Student #2 modified the sketch of the steps and platforms to accommodate for smaller children (Graphical Modelling). He then sketched the platform and decided that it should be as wide as the bars and wide enough "for one person but not too wide as to fit two people." He guessed that about two feet would be appropriate (Mathematical Description). Lastly, he restated all of the measurements with regard to the monkey bars (both sets of bars and platform) and documented them (figure 10).

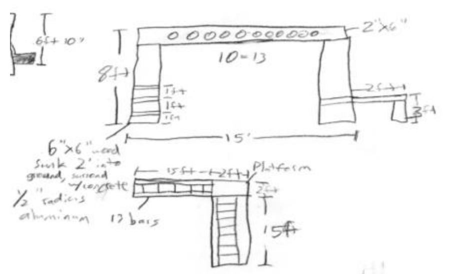

Figure 10. Student #2's monkey bar sketch.

Student #2's modelling was focused on sketching (Graphical) and documenting size (Mathematical Description).
He repeated this sketching and documenting cycle throughout his modelling and design session.

Student Case #3 (study participant 3306): a student that used graphical models during design.
Before participating in the design challenge, Student #3 had taken four technology and engineering classes. Student #3 indicated that she believed that brainstorming, building, communicating, making

decisions, testing and understanding the problem were the most important factors to consider during design. Additionally, she indicated the least important activities in the design process were abstracting, generating alternative, goal setting, making trade-offs, seeking information and visualizing. Student #3 spent over an hour and a half engaging in the design activity. As shown in figure 11, Student #3 made fewer iterations than the two previous cases. She considered the problem a few times early in the process while simultaneously gathering information and generating ideas. She spent the bulk of the remaining two-thirds of her time modelling. She considered the feasibility of her ideas a few times during the session. She did not make any noticeable comparisons between alternative ideas (evaluation) nor did she make decisions by selecting one of the alternatives. She spent a substantial amount of time sketching but did not make clear that the purpose of her drawing was for communicating the design to a builder. The vast majority of her time was graphical and she engaged in one episode of description and explanation.

Student #3 spent nearly all of her time (99%) creating and using graphical models. She would engage by making lists, sketching the overall layout, and providing detailed drawings of specific playground design features. She rarely (1% of her time) engaged in mathematical modelling, and that was to setting up a scale for her drawing. While "modelling" was her primary method during design, it was difficult to determine what, if any, design decisions she made in relation to her graphical models.

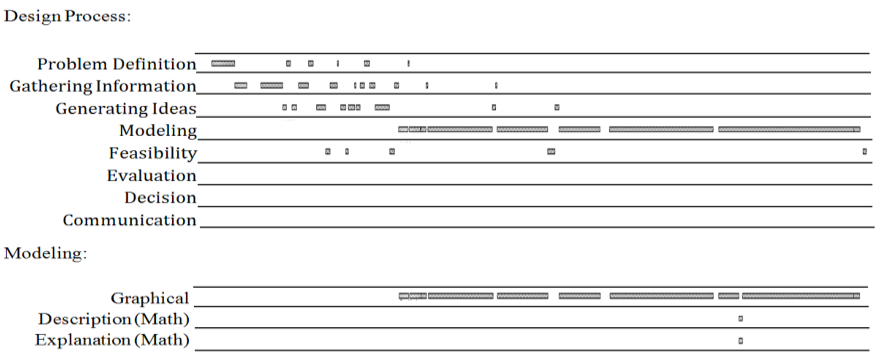

Figure 11. Timeline for Student #3 (study ID: 3306) showing design and details on type of modelling used.

Student #3 utilized sketching and drawing to both model and communicate her designs. While creating her overall playground layout (figure 12), she first created an appropriate scale. Next, she placed different design features (monkey bars, soccer field, benches, etc.) and used her drawing to spatially decide where design features will be located.

When designing individual features, Student #3 indicated that someone simply "needed to build her designs from her drawings". However, she gave no details on material usage, cost or building or other details required to build directly from her drawing. Although she omitted any mathematical or verbal rationale on why she chose the specific design features, she could be observed iterating between her two primary graphic models; overall layout and individual design feature sketches. In the post-design interview, she indicated that her decisions were made based on her previous experiences with playgrounds as a child.

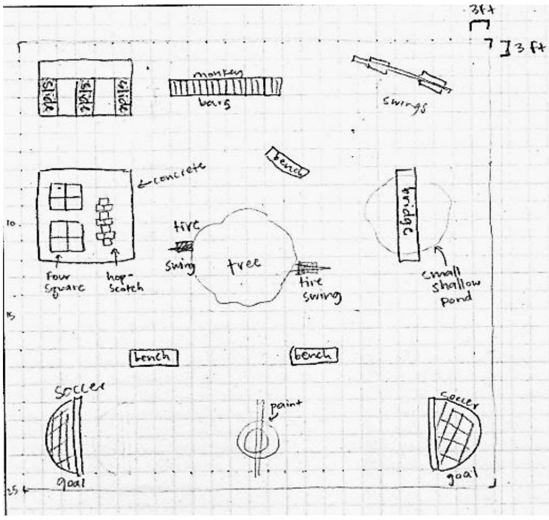

Figure 12. Student #3's playground layout

Student #3 began by creating the overall layout of the playground (Graphical). She replicated the plot provided and created a scale. She stated that, "while [I] was drawing the layout, I thought of a better idea for the slides." She indicated that a platform with multiple slides would be better than multiple individual slides. She then continued to sketch different design features (Graphical). She frequently looked back-and-forth between layout drawing and individual design feature sketches (figures 12 and 13).

Student #3's modelling time was spent sketching the overall layout and individual design features. She would cycle between the two graphical models, checking to see if the design met some level of visual satisfaction. As she did not express specific criteria and constraints, it is difficult to deduce what, other than personal experiences, informed her design decision.

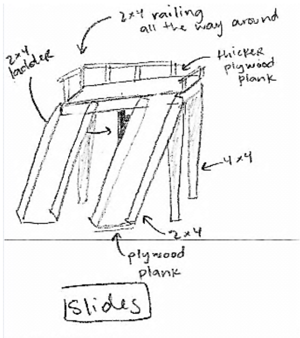

Figure 13. Student #3's individual design feature sketch.

6. Discussion

Results suggest that few students are engaged in mathematical modelling while most are spending substantial amounts of time modelling graphically. Graphical modelling is a significant element as described by the NAE [2] and ITEEA [28, 29] but not the only element of modelling. The overwhelming imbalance between graphical modelling and other types help to explain that the students are spending time modelling at the high school level [3, 30]. However, the lack of mathematical relationships and functions leading to explanations of design decisions is problematic. All students in this study had taken multiple engineering or technology courses including courses with a focus on engineering design. The students' lack of effort modelling mathematically calls into question the nature of their ability to think as engineers do.

The three students investigated with the case study methodology developed patterns of modelling. Each of the three students' patterns were different from the others, but they were consistently applied during the design problem. The patterns, represented visually in the results section, were repeated in a series of cycles as students worked toward a final solution. This repeated application of the pattern of modelling indicates the students are purposefully thinking using a structure that they may have learned previously and are applying in this problem. Students applied this pattern on multiple levels with similar outcomes. They modelled on a holistic level (cost of the entire playground, space layout of the entire playground), at the feature level (how much will the slide cost, how will the slide look) and at the material level, (2x4x8 costs a certain amount while a 2x4x16 costs a different amount, and this is how a 2x4 would look visually). The application on different levels provides indication that student thinking is consistent and based on a preconceived notion of how engineers function.

In the cases studied, Student #3 and Student #2 did not use mathematical models to inform decision making. Student #2 made attempts by quantifying distances and stating that he remembers a relationship exists, but could not apply it. His lack of ability to transfer a simple Pythagorean Theorem application should be concerning for educators as transfer is a significant element of learning. Students who learn material in mathematics courses, such as Pythagorean Theorem, should be able to apply it in a similar context to drive a decision making process. Student #3 did not comment on the desire to create mathematical relationships as Student #2 did, and it is unclear if the cause was that she did not see the benefit in describing or if she thought that was not part of the design problem. Of the twenty students, most did not explain their design decisions with mathematical relationships or functions and further investigation might answer why.

7. International Implications of Research

Problem definition is a critical step in design thinking. It is the first stage of engineering design and it sets the foundation for developing solutions. Atman et al. believed that experts tended to spend more time on this stage [27]. Jain and Sobek [31] found the more time students spent on problem definition, the more satisfied the clients were. "Research has uncovered differences in the breadth of problem-scoping exhibited by "novice" student engineers and "expert" designers, who are typically advanced professionals with significant work experience" [32]. Christiaans and Dorst [33] suggested novices looked for less information and demonstrated less thorough problem scoping in comparison to expert designers. High school students in this study were inclined to spend insufficient time on problem definition and jump to the phase of finding solutions. Students seldom revisited the problem during the process of design. From a qualitative perspective, student designers did not understand the problem at hand. They also did not make substantial efforts to understand the problem; rather, they were quick to engage in the solution space with results that failed to align with the problem. Students demonstrated capacity for asking questions, but their efforts focused on questions about the solution, including cost of materials they wished to use. Few asked about location, use, users, clients, goals or objectives of the stakeholders. Even constraints presented in the problem were often unconsidered.

Practitioners should consider a few aspects of this research: information gathering, modelling, and decision making. Students in this study spent very little time brainstorming. While students may memorize the purpose and procedure of brainstorming, few students in this study had internalized the method. Further research should investigate the impacts of information access on solution quality for younger learners. The balance between becoming fixated on finding information related to the problem and using that information to make decisions is delicate and may be difficult for novice learners.

Practitioners should address the general lack of mathematical modelling and decision making from these results as an area to strengthen in their classrooms. Curriculum and teaching methods should be reviewed for their treatment of analysis as a method of modelling. Teachers need to emphasize the role of analysis such that students can apply these techniques in the context of the problem at hand. Analogical reasoning is often used in engineering design and should be included in engineering design curriculum and instruction [34]. Decision making should be based on data derived from analysis and information gathered.

Results of this work are troubling as they suggest that after four or five engineering related courses, seniors in high school, many of whom plan on pursuing engineering, do little or no mathematical modelling. Future research should investigate why modelling appropriate for engineering is nearly absent from high school student thinking. Interventions as supplements to existing large scale curriculum efforts may provide support for teachers and students as they integrate modelling more appropriately in to the classroom. Research should test interventions for developmental appropriateness.

8. Acknowledgement

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Presenter: The paper is presented by Kurt Becker

Protecting Student Privacy and Data in the Age of Surveillance

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Abstract

The recent revelations that the U.S. government may be collecting large amounts of communications data from international citizens have re-energized the debate about Internet privacy and security. Educators are increasingly incorporating cloud-based e-learning solutions into the classroom, including hosted services and mobile applications (M-Learning) which can be privacy-invasive. The Facebook generation of students routinely and naively shares large amounts of personal data online. However, how this data is subsequently used by private corporations and governments is not well known. Although online advertising platforms claim to only record aggregate data about users, new technologies such as browser fingerprinting and face recognition technology allow for the easy identification of individual devices as well as users. The largest technology companies such as Google, Apple, and Microsoft maintain servers based in the U.S., thus a significant pool of international student data may potentially be exposed to review or seizure both by internal employees ('malicious insiders') and government agencies with little or no judicial oversight. Drawing on the author's expertise in e-learning, a survey of the relevant peer-reviewed literature, anecdotal evidence from a variety of sources, and systematic review of privacy watchdog websites, this study: 1) first establishes that the threats of Internet security and privacy to student online learning are underestimated and misunderstood by many educators, 2) then identifies the key risks to students, and 3) finally recommends practical means of reducing privacy threats to students in online learning environments.

Keywords: *Internet privacy, E-learning, Hosted services / cloud computing—privacy and security*.

1. Introduction

This contribution examines web-based educational resources that make use of private corporate hosted services, also known as cloud computing. This paper does not address the storage of protected student data in in-house institutional electronic databases since these privacy and security issues have largely been resolved (although the problem of malicious insiders still exists) due to the restrictions and penalties of the U.S. Family Educational Rights and Privacy Act (FERPA), which prevents the disclosure of student data. The U.S. FERPA law of 1974 gives non-dependent students over 18 the right to privacy in grades, enrolment and financial information related to their status as a student.

The potential severity of online privacy risks has been obfuscated by both governments and private Internet businesses who both share a vested interest in asymmetrical information-gathering practices in which individuals are manipulated, deceived, or coerced into providing private information about themselves while at the same time they are unable to discover how this information is collected, analysed, stored, and sold. Online SNS and hosted service privacy is not yet a large concern among educators, even in the e-learning community. For example, in Karen Kear's *Online and Social Networking Communities: A Best Practice Guide for Educators*, social network privacy is only discussed briefly once in the entire book. [1] In addition, most how-to guides on using social networks for business purposes do not discuss privacy, and in fact in four recent business manuals on social media strategies published 2011-2012 there is not a single index entry on privacy. [2] This is because the business model of SNSs is based on maximizing the collection of personally identifiable information (PII), aggregating it with other data, and then reselling it to advertisers who generate user-specific ads. Cloud computing itself has a number of related and serious unresolved privacy and security issues, such as the vendor's ability to access stored data or data mine it, data retention policies, protection from hacking and malicious insiders, and contingencies for bankruptcy of the provider or loss of service, which are slowly being solved by the industry. [3]

In cloud computing and hosted services, application processing is accomplished on remote servers belonging to the host, and data generated or uploaded by users is often stored by the hosts, and sometimes online behaviours of users while using the host are also tracked and stored. Examples of hosted services include Social Networking Sites (SNS) such as Myspace, Orkut, Renren and Facebook, and productivity and storage services and platforms such as Dropbox, Google Docs, Gmail, Windows Azure, and Amazon Web Services, etc. Benefits to using these services for educational or administrative purposes include: many services are free, anytime / anywhere access as with most web-based e-learning applications, reduction or elimination of in-house IT staff to maintain electronic resources, connecting learners world-wide and crowd-sourcing of knowledge (peer tutoring), creation of collaborative learning communities, and the ubiquity of hosted resources across multiple platforms and devices (tablets, cell phones, PCs), to name just a few.

Recent research into the impact of SNS use on academic performance and outcomes has been equivocal, but the time displacement theory (that SNS use is primarily recreational and detracts from academic activities) is persuasive. [4-9] According to a Pew Trust survey, in 2012, 83% of American online adults used a social networking site. [10] Some good news is that in an additional survey of 802 online teens, 60% kept their profiles private, indicating that they possess some awareness of reputation management and privacy threats. Unfortunately, only 9% of teens were 'very concerned' that third parties had access to their data. [11] This low figure, as will be demonstrated below, argues for institutional education programs about Internet privacy as well as proactive steps to ensure student privacy. Another argument for increased attention and awareness to privacy issues is that given the wide range of tracking and surveillance technologies available today, it is extremely difficult even for an educated adult to manage their own personal privacy on the Internet, let alone a student or Internet neophyte.

Social networking is becoming an integral part of both student and adult online experience: for example, Facebook reported 1.15 billion active monthly users as of June 30, 2013 and 1 million active advertisers. [12] Many hosted services provided by Google and Facebook derive most of their revenue by selling advertisements and employ Behaviourally Targeted Marketing, which serves up web advertisements that customers are "likely to find interesting. If advertising better matches consumer interests, consumers are more likely to respond to the message." [13] Thus the more that an online company can learn about a person's behaviour on the Internet, including sites visited, buying habits, friends, income level, age, gender, and other personal details, the more valuable that information becomes since it can create a personal profile of that person and their consumer behaviour. Once this fundamental business plan is understood, then it becomes clear that companies using it will continually attempt as a matter of policy to minimize privacy and maximize the amount of PII collected through a variety of strategies, such as: changing privacy policies without notice, obscuring privacy practices through legalese or inadequate disclosure, setting default privacy settings to maximum sharing, or outright deception (Google recently exploited a bug in the Apple Safari browser to repopulate tracking cookies to bypass users' privacy settings). The personally identifiable information available on SNSs can be correlated by third party servers (typically advertisers) with tracking cookies so that a user's browsing history and Internet behaviour can be recorded and traced to a specific individual, across websites, even when the user leaves the site that installed the original cookies. [14]

2. Methodology

The research is based on the author's anecdotal evidence in teaching in various online environments in the State of Qatar and previous institutions, as well as anecdotal evidence from online blogs, forums, media reports and general interest technology magazines (such as Wired. com) to establish the extent and severity of the relevant technical, legal and social issues as well as awareness of these concerns among educators and the general public. Due to the late adoption of the Internet in the MENA region because of attitudinal barriers and lack of Internet infrastructure, general public and educator knowledge about online fraud, deceit, bullying, and slander is unfortunately low. Thus the issues in this paper are of particular concern to the educational systems of the developing world.

The author then surveyed the peer-reviewed scholarly literature on Internet privacy and security in e-learning and social networking environments. Internet privacy watchdog groups' websites were also systematically reviewed, including the Electronic Privacy Information Center (EPIC), Electronic Frontier Foundation (EFF), and World Privacy Forum (WPF). Key privacy issues and their real and potential consequences were abstracted and analyzed from the above searches, and best practice recommendations were generated. In addition to the author's recommendations, a list of the most up-to-date, accurate, and user-friendly privacy guides for educators available from secondary sources was compiled and reported (Table 1).

3. Findings

3.1. Is Online Privacy a Serious Legal and Social Concern?

The concept of privacy–which roughly can be defined as the ability and desire to isolate oneself from the greater society and control information about the self or one's personal belongings–varies greatly across cultures. The Fourth Amendment of the United States Constitution (Bill of Rights) guarantees "The right of the people to be secure in their persons, houses, papers, and effects, against unreasonable searches and seizures, shall not be violated, and no Warrants shall issue, but upon probable cause, supported by Oath or affirmation, and particularly describing the place to be searched, and the persons or things to be seized." Although originally directed against potentially abusive government action against citizens (as had occurred in the 17^{th} and 18^{th} centuries in the English colonies and with the French King's extra-judicial *lettres de cachet*, a grievance that led to the French Revolution), the Fourth Amendment could logically and philosophically, although not legally, be applied equally to abuses of corporations and individual citizens against other citizens. An 1890 article in the *Harvard Law Review* by Samuel D. Warren and Louis D. Brandeis established the principle of 'the right to be left alone.'[15] Some individuals believe that it is a fundamental and basic human right not to be forced to reveal personal information to another party, such as one's sexual orientation, health or financial status, etc. except where required by law; for example, income tax law requires the sharing of personal financial data with government authorities. Privacy is closely related to security on the Internet, since personal information gathered from the Internet or stolen from protected databases or mined and aggregated from hosted services servers can be used by another party for fraud, theft, libel, defamation, and harassment (cyberbullying).

Surveillance and data gathering can also be helpful or benign; for example, when law enforcement can monitor known or potential suspects to increase public safety, and corporations can offer more targeted and relevant information (ads) about products based on past buying behaviours. Thus privacy debates often argue along the lines of a security-convenience/privacy trade-off. One problem, however, with surveillance and collection of private information without user consent is that in and of itself surveillance infringes on various freedoms that are increasingly being viewed as basic human rights, such as freedom of speech, thought, and association.

In addition, dragnet surveillance that targets everyone plus lack of oversight and transparency increases the danger that innocent people will be targeted: for example, the Electronic Frontier Foundation found "evidence of the U.S. government using social media sites for data-gathering, including that the U.S. Citizenship and Immigration Services uses social media sites to evaluate citizenship requests, that the Internal Revenue Service is poking around social networking sites to investigate taxpayers, and that the DEA is looking at social graphs of connected friends in order to map out associates of those sought in investigations." [16] For example, if an international student wishing to study in the U.S. has an anti-American friend on Facebook–which for American citizens would be part of their right to freedom of association–she may find her visa application denied without an explanation for the refusal.

3.2. Practical Implications of Internet Privacy

A recent Pew Trust survey revealed that large numbers of teens (the majority) are revealing a surprising array of personally identifiable data on social networks including photo (91%), school name (71%), city (71%) and email (53%). [17] Since roughly 40-50% of social networking users keep their profiles entirely public, this information is open to anyone, and also is available to the SNS service provider and can be reposted elsewhere on the Internet by friends or acquaintances within the user's network even if the profile has restricted access.

A common argument concerning Internet privacy is 'If you are not doing anything immoral or illegal online, you should not be concerned about Internet privacy.' However, this is a false argument since individuals often wish to keep personal information private about their status or activities that are not necessarily illegal or immoral – for example, HIV status can be the cause of discrimination, as well as homosexual activity which in some countries is illegal and could have serious repercussions. If past criminal history is publically disseminated, particularly as a juvenile, and if an individual has paid the penalty of past wrongdoing, expresses remorse, and has changed their behaviours, then publically broadcasting previous criminal activity represents 'double indemnity' or being tried for the same crime twice; the individual may be judged and condemned for past acts for the rest of his or her life.

Another obvious advantage of maintaining Internet privacy is to reduce the likelihood of identity theft, which is now a well-documented and very damaging crime. Online information brokers such as Spokeo, Acxiom, Choicepoint, People Lookup, etc. are now aggregating public records, legal documents, and electronic purchase records with social networking data. Unfortunately, it is difficult for an individual to correct or remove inaccurate data, or control the data assembled by aggregators. Acxiom and other data brokers were investigated by the Federal Trade Commission (FTC) about potential illegal or deceptive private data gathering practices. Also, ironically since its databases can be used in background checks to combat bank and identity fraud, the data aggregator Choicepoint was involved in a serious identity theft scandal in 2004. Identity thieves opened accounts with Choicepoint and gathered the personal data profiles of more than 163,000 customers which they used to perpetrate 5,000 instances of identity fraud and theft. The FTC fined the company $15 million USD in 2006 over the security breach. Even if secured from outsiders, databases containing private confidential data may be abused by those with lawful access to them. The privacy watchdog Big Brother Watch has detailed the misuse of confidential police databases by UK police between 2007 and 2010. Between 2007 and 2010, 243 police officers and staff were convicted, 98 had employment terminated and 904 were subject to internal discipline for breaching the Data Protection Act (DPA). According to Daniel Hamilton, "Police employees [have] been found to have run background records checks on friends and possible partners, but some have been convicted for passing sensitive information to criminal gangs and drug dealers." [18]

Cyberbullying, stalking, and harassment are also facilitated by revealing personal information online, in that it provides opportunities for attacking vulnerabilities of victims, and can escalate to real world violence if the victim can be physically located by the victimizer. Several high profile cases include Canadian teenager Amanda Todd, who endured bullying in British Columbia before committing suicide and Tyler Clemente, who jumped from a bridge after being filmed during a homosexual encounter with a webcam by his room mate. The Megan Meier case, in which a neighbour Lori Drew and her daughter posed as a sixteen year old boy, befriended Meier on the SNS Myspace, and then sent abusive messages to her which prompted her to commit suicide, sparked new cyberbullying legislation. In response to Lori Drew's acquittal for harassment, the Missouri State Legislature voted in a bill known as "Megan's Law" in 2008 which increased penalties for anyone who "knowingly frightens, intimidates, or causes emotional distress to another person by anonymously making a telephone call or any electronic communication." [19] Although some social scientists, educators and psychologists argue that online bullying is no different from normal real-world bullying, there are differences: text, photos, and sound can be easily modified to present false facts about a person, fake accounts can be created online, and libel and slander can be rapidly and widely disseminated electronically. Also, as Lidsky and Friedel point out, "the victim may fear that anything said about her may be searchable indefinitely and thus haunt her for years." [20]

Spear phishing is a form of Internet crime facilitation in which thieves glean PII and use it to impersonate friends or plausible official personalities in order to trick the victim into revealing even more sensitive and valuable data, which can then be used for illegal purposes. A famous spear phishing experiment is the famous "Satan is on my friends list" in which experimenters successfully impersonated a well known security researcher on social media without raising any suspicions. [21] Privacy concerns are now emerging from other quarters, including smart grids and smart appliances, which are Internet-enabled home devices or electrical sources that record and monitor data to optimize usage and efficiency. However, stored data patterns can reveal numerous pieces of personal information such as consumption patterns, health status, visitors, home occupancy, etc. The province of Ontario, Canada is leading the way in integrating privacy into devices and electric grids before they are deployed into homes by ensuring that private data is sufficiently anonymized to protect individual and household identity. [22]

The popularity of Location Based Services also represents a potential privacy concern. Mobile device applications (apps) which deliver valuable information to customers based on their location (such as the location of restaurants and hotels), also collect the location data and can sell this to other businesses. In 2010, a *Wall Street Journal* investigation found that "an examination of 101 popular smartphone 'apps'—games and other software applications for iPhone and Android phones—showed that 56 transmitted the phone's unique device ID to other companies without users' awareness or consent. Forty-seven apps transmitted the phone's location in some way." [23] Mobile phone cell tower triangulation data, which is recorded, can locate a person within approximately 100 meters and this data is frequently requested by law enforcement. In 2009 U.S. telecom Sprint indicated that its automated data request system had been used over 8 million times within 13 months. [24] The potential abuse problems associated with online or cell phone location-based tracking are: general intrusion of privacy, revealing your home location to others (i.e. vandals who may commit hate crimes against you because of your race, sexual orientation or religion), being stalked, allowing someone you are trying to avoid to find you, potential for unwarranted search or seizure, and guilt by association (being tracked near a crime scene or demonstration). [25]

Another aspect of online activity in which privacy plays a role is 'Reputation Management,' controlling and managing the persona that other users see online. While students become adept at managing reputation on SNSs from an early age just as they do in real life, they are often unaware of the future consequences of public online activity. Few realize that according to most SNS privacy policies, data posted to SNSs belong to the site legally (or the site retains the right to copy and use the data) and are retained in perpetuity. Since students may not possess credit cards or bank accounts containing substantial amounts of money, they are generally unconcerned with divulging information that could lead to financial loss. Also students may be unaware that their SNS profiles could be accessed and reviewed by a potential employer in making hiring decisions, even if the SNS profile is not viewable by others outside the chosen circle of the individual, since data can be sold to an aggregator, who subsequently resells it to an employer. Although there are no legal restrictions on employer background checks using SNS searches of personal profiles, Clark and Roberts argue that these checks are inherently unethical from a business ethics standpoint as they impinge on personal privacy. [26] As pointed out by the Privacy Rights Clearinghouse, the private data mined from SNS sites could impact the following important life decisions, which may affect both high school and college students after they graduate: "renting an apartment, beginning to date someone, starting or maintaining a professional relationship, for example as an independent contractor or in a managerial position, engaging in volunteer or electoral positions, applying for colleges or scholarships, [and] being considered in a jury selection process." [27]

4. Conclusion

4.1. Recommended Practices for a Privacy-Invasive Internet Ecosystem

Critical educational data, such as student performance and health records, should only be stored in cloud services if they are encrypted and the institution has done a risk analysis to determine if the privacy and security regime of the provider is robust and can be trusted based on past experience and corporate behaviour. However, the use of SNSs and the open sharing concept of today's online ecosystem can create leakages of this same personal data from the data holders themselves from public self revelation, often with little understanding of the broader consequences. Therefore education is a key component in helping students maintain positive and secure online learning experiences. This includes education in using browser settings properly, social network site privacy settings, and teaching the real implications of identity theft, public dissemination of personal data, and improper reputation management.

Since the topic of Internet privacy and security contains so many debatable, engaging and highly relevant facets of modern life in online space (free speech, personal freedom, copyright, digital rights, relationship of individual to the state, social relations), Internet privacy can be the subject of in-class discussions and projects. Thus the subject can be taught in its philosophical, humanistic, or political dimensions which makes use of general critical/analytical thinking skills and formal argumentation and rhetoric, while at the same time providing practical online skills and knowledge about how the Internet works from a business and financial perspective. This recommendation will require teacher training, however, and privacy and security training modules should be integrated into all post-graduate teacher training programs in which instructors will be expected to use e-learning tools or hosted services on the Internet. Table 1 provides some easily accessible online privacy guides for teachers.

Table 1. Social Networking Privacy Guides for Educators

Organization	Name of Resource	URL
Privacy Rights Clearinghouse	*Fact Sheet 35: Social Networking Privacy: How to be Safe, Secure and Social*	https://www.privacyrights.org/social-networking-privacy/#general-tips
EPIC	*Social Networking Privacy*	http://epic.org/privacy/socialnet/
WPF	*Cloud Computing Privacy Tips*	worldprivacyforum.org/pdf/WPF_Cloud_Tips_fs.pdf
New York Times	*Staying Private on the New Facebook*	http://www.nytimes.com/2013/02/07/technology/personaltech/protecting-your-privacy-on-the-new-facebook.html?_r=0

Legislative remedies in the U.S. could at the minimum simply extend the stricter privacy and data protection provisions of the COPPA and HIPAA and HITECH laws (which protect children and health consumers) to *all* online users. For example for a HIPAA violation (as an example, releasing a famous individual's electronic health record to a news source) which is due to wilful neglect and is not corrected carries a $50,000 USD fine per violation, with an annual maximum of $1.5 million USD. Penalties such as these would force all online corporations to rigorously pursue security of their stored data.

Educational institutions who are heavily invested in e-learning and social networking and hosted services for pedagogical purposes should establish a 'Risks and Threats' committee, preferably composed of senior administrators, any personnel with a legal background, and IT personnel who understand thoroughly the technical aspects of privacy and security. IT personnel must actively monitor IT news sources and security websites to counter emerging privacy threats.

4.2. General Online Privacy and Safety Tips

1. Use and update virus protection programs – they can detect malware programs that steal private data for malicious purposes
2. Install software updates when requested – these patches often fix security holes
3. Familiarize yourself with any built in security systems – i.e. Macintosh OS X features a firewall, and native disk and file encryption
4. Turn off sharing services if not in active use – these include Bluetooth, Wifi (wireless Internet), and Near Field Communications (NFC)
5. Actively maintain web browser cookie settings – settings are browser dependent; third party cookies are generally advertising networks; delete cookies after leaving a site; some sites may not function if authentication cookies are not installed.

4.3. Privacy Tips When Using SNSs and Hosted Services Sites

1. Don't reveal publically your home address or cell phone in conjunction with other identifiable data
2. Read the entire privacy policy of a site
3. Check the identity of strangers sending 'friend', connect or share requests
4. Do not respond to online requests asking for personally identifiable data to an unknown entity; if in doubt check if the URL or email header matches the purported identity of the requester
5. Never reveal a password online
6. Use encryption – use the 'https' version of a site if available; this reduces 'man-in-the-middle' attacks
8. Consider using an online proxy or VPN that obscures your Internet IP address
9. Turn off location-based services (geolocation) if not being used, and check if your camera or cell phone is automatically tagging photographs with hidden GPS coordinates
10. Use strong passwords (see *NIST Guide to Enterprise Password Management (Draft): Recommendations of the National Institute of Standards and Technology* [28])
11. Use an online pseudonym if allowed by the service (may violate Terms of Service).

Institutions may wish in addition to install Virtual Private Networks (VPNs) or proxy servers with encryption for student use. VPNs unfortunately can degrade network latency. Educators who are deeply concerned about these issues may wish to join one of the Internet privacy advocacy groups, such as EPIC, WPF, EFF, PRC, and Big Brother Watch. Educational institutions may consider centralizing computer and mobile device usage, which is a common practice throughout the world. For example, school issued laptops can be required (banning bring your own device (BYOD)), only for use for academic activities. Thus IT administrators can control a variety of preferences to restrict Internet activity and filter and block undesirable websites (the NIST guide on securing mobile devices is helpful in this regard). [29] However, administrators should balance learning, freedom, growth and discovery with adequate online protections. Another option would be to not use SNSs or hosted services at all in educational settings. Most of the educational functionality of SNSs (bulletin boards, messaging, chat, posting, links, embedded video) is already incorporated into Learning Management Systems such as Blackboard, Moodle, and Canvas. Educators can scan SNS sites and apps stores for educational ideas which can often be re-created using existing and more privacy-friendly and secure applications.

Education about privacy risks and concerns on the Internet, specifically Social Networking Sites, and hosted (cloud-based) services based on free-services/advertising models is critical to protect students from potential threats to their finances, reputation, proper social development and employment prospects. According to Debatin "The first step toward regaining agency and responsibility is the development of an enlightened understanding of technology and its unintended consequences….users must inform themselves proactively about the potential negative impact of social media on their privacy and that they must acquire the skills necessary to mitigate or entirely prevent negative consequences." [30]

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Correlation between using Netspeak standards inside closed online discussions within the same generation of students in the first then in the seventh semester

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Abstract

Online discussions are very important part of any e-learning system. Closed discussions are related to the teaching content and can be professor – student (P-S) or student – student (S-S), depending on who is the moderator. With rapid development of new technologies and everyday use of new communication channels such as Facebook, Skype, MSN, SMS, etc., a new form of written language called Netspeak has emerged. In order to measure the quantity of Netspeak, ten different standards have been developed that can be divided into four groups: standards related to information and communication technology (ICT), grammar and spelling (G), prosody (P) and others (O). In this paper, the authors conducted a content analysis of closed asynchronous discussions within the same generation of students in the first then in the seventh semester, measured the amount of Netspeak and investigated whether there is a correlation between the use of Netspeak at the beginning and end of the study program. The quantity and density of Netspeak standards in P-S and S-S discussions will be particularly analyzed.

Keywords: *Asynchronous online discussions, Closed discussions, Students.*

1. Introduction

Asynchronous online discussions make very important part of any e-learning system [1]-[3]. In their paper Steimberg & etc. analyze three groups of online discussion participants [4]:

- active participants who write posts and actively participate in the discussions
- passive participants who read the posts but do not participate actively in the discussion
- participants who do not participate in the discussions

Modern Learning Management System (LMS) can monitor the rate of the activities in different modules including active or passive participation in online discussions. In this paper the amount of Netspeak [5, 6] elements within the online discussions is measured, and furthermore analyzed only the online discussions of the active participants.

In the paper „Important Role of Asynchronous Discussion in E-learning System“[7] the authors define the open and closed discussion. Open discussions are meant for informal communication between professors and students (P-S), students and professors (S-P) and among students (S-S). Closed discussions are related to the lecture content and depending on whether the moderator is a professor or a student; the discussion could be professor-student discussion (P-S) or student-student (S-S). In the literature, particular attention is paid to the discussion between students because such discussion creates a special atmosphere for the development of high-quality discussions. [1]

Meyer have developed several methods for analyzing the content of the discussions [8], but in this paper, due to the specific content related to Netspeak, other methods of analysis are used.

2. New language form – "Netspeak"

Defined as the special language, abbreviations, and expressions used by people when communicating using the Internet [9] Netspeak is also the characteristic mode of speaking, peculiar to the Internet and online communication, moreover, its typically used jargon. It emerges in online discussions via Skype, Facebook, MSN, e-mails, and it is developed within them. The technology, in a way, shapes the communication. As McLuhan said „we can characterize the ages of humanity, as, if not determined by, than at least reflective of, prevailing communicative technologies.“ [10] Stating, furthermore that „ideas and technology interacts, becoming virtually identical, in the sense that the medium is the message.“ [10]

2.1. Standards for measuring the quantity of Netspeak

In the paper „Standards for measuring the Netspeaks quantity in on-line text content“ authors have defined 10 standards for measuring the quantity of Netspeak elements. [11] Table 1 shows the standards for measuring the quantity of Netspeak elements grouped into four categories: [12]

1. ICT standards (I1, I2, I3) – related to the use of English words in the Croatian language, the use of abbreviations, acronyms and emoticons.
2. Grammar and syntax (G1, G2, G3) – related to the extended use of lower cases through the whole text regardless the punctuation and proper names, the omission of diacritics and the omission of space after punctuation.
3. Prosody standards (P1, P2, P3) – the nonstandard use of punctuation, the use of upper cases when lower cases are needed and the prolongation of the graphemes.
4. Other – all other elements that can appear in the discussions and within other communication channels, such as social media.

Table 1 shows the ten standards and its description [11] the value of each standard is 10% and is the same for each standard.

Table 1. Netspeak elements quantity measuring standards

STANDARD	DESCRIPTION	P
I1 – English words	New technologies development is based on English language so it happens that Croatian language is subjected to overwhelming English words.	10
I2 – acronyms and abbreviations	Acronyms and abbreviations are composed of the initial letters of each member of the expression in them. Abbreviations are mixed; there are regular and occasional ones. There are common abbreviations that are short parts of words or sets of words, and read as if words are spelled correctly. Other abbreviations are formed by merging the initial letter or letters of multi-member group called names and is usually read as written.	10
I3 – emoticon	Emoticons are signs, symbols. They are not just colon and parentheses; it is a sign of a good mood, and sometimes takes other meanings depending on the context in which it is used. Symbols are signs in which the relationship between signifiers are already learned.	10
G1 – lower case graphemes	Contrary to the grammar rules, the use of lower case graphemes where it should be used upper case graphemes.	10
G2 – diacritics special signs	Part of the grapheme that change the sound of the grapheme. Those signs are omitted and often recorded by the standard rules of English language.	10
G3 – Space	The omission of space where needed, after punctuation.	10
P1 – punctuation	Punctuation is used in a non standard way in order to compensate the auditive channel within the discussion.	10
P2 – uppercase graphemes	In written Croatian language there is standard use of uppercase in three particular situations. First is with the proper names, the second as the first letter in a sentence and finally in order to express politeness. Though, there are some exceptions. Uppercase within the whole word, sentence or text can be used for esthetic, advertising or propaganda reasons. It is used in order to emphasize the specific word and to plan and to add the prosodic elements to the written word.	10
P3 – prolongation of the	In written Croatian language there are 30 sounds each represented by single grapheme	10

graphemes	(except three sounds being represented by double graphemes *dž*, *lj* and *nj*). There's no such a thing as geminate (a double consonant such as *mm* and a word *communication*). It is used in order to add prosodic elements to written words. Prosody gives rhythm and melody to a word. It comprehends acoustic parameters such as accent, intonation, and melody.	
O – Other	Use of tense considered to be obsolete – aorist. As far as the past tenses are concerned, the most frequent and the most dominant tense in contemporary Croatian is the Croatian *perfect* - *Vidjela sam te* (PERFECT – *to see*). Shortened form, *aorist* form would be *Vidjeh te*. (AORIST – *to see*).	10

In the study conducted by Aleksic-Maslac & etc. the results show the higher quantity of various Netspeak elements used in the first semester of study program then at the end of it. [13] In the extension of this paper, the authors analyze the quantity of the Netspeak elements used within the same generation of the students, using ten standards as well as using the density rate of the characters. [12]

3. Research and result

Authors analyze the closed online discussions conducted at Zagreb School of Economics and Management within the same generation of students in two courses with richly developed closed discussions.

- ICT (Information and Communication Technologies) – 1st semester – academic year 2009/2010
- MIS (Management Information System) – 7th semester – academic year 2012/2013

Table 2 shows the number of posts and the number of analyzed characters. 624 posts are analyzed within the ICT course in the first semester, while 461 posts are analyzed within the MIS course in the seventh semester. It is an extensive analysis of the content of 312 512 characters in the ICT course, and 311 095 in the MIS course. The characters include space since the standard G3 refers to the omission of the space after punctuation.

Table 2. Number of analyzed posts and characters including space

Number of posts					Number of characters (with spaces)			
1st semester		7th semester			1st semester		7th semester	
P-S	S-S	P-S	S-S		P-S	S-S	P-S	S-S
342	282	308	153		212 817	109 695	219 116	91 979

Table 3 shows the amount of each Netspeak standard and the Netspeak density counted by a number of characters.

Table 3. Netspeak standards and the Netspeak density

	Netspeak standards					Netspeak density			
	1st semester		7th semester			1st semester		7th semester	
	P-S	S-S	P-S	S-S		P-S	S-S	P-S	S-S
I1	8,6	8,2	8,6	9,4		5,20	5,36	3,23	6,16
I2	6,8	4,9	7,3	6,2		1,23	1,04	1,07	0,76
I3	3,0	4	1,1	2,9		0,1	0,56	0,04	0,30
I (∑)	18,4	17,1	17	18,5		6,53	6,96	4,34	7,22
I (%)	56,3	47,8	70,3	69,6		68,8	62,3	88,6	90,25
G1	2,0	3,7	0,9	1,7		0,22	0,57	0,03	0,14
G2	3,9	4,3	1,6	1,0		1,08	0	0,26	0,18
G3	2,0	2,1	2,0	1,6		0,22	0,28	0,09	0,05
G (∑)	7,9	10,1	4,5	4,3		1,52	0,85	0,38	0,37
G(%)	24	28,1	19	16,1		16	7,6	7,8	4,6
P1	5,0	6,8	0,9	1,7		1,05	1,97	0,05	0,28
P2	0,6	0,7	0,3	0,2		0,14	0,59	0,04	0
P3	0,8	1,1	0	0,1		0,07	0,37	0	0,01
P (∑)	6,4	8,6	1,2	2		1,26	2,93	0,09	0,29
P(%)	19,5	24,1	4,9	7,6		13,3	26,2	1,8	3,6
O (%)	0,2	0,2	1,4	6,7		1,8	3,9	1,8	1,55
∑	**32,7**	**35,8**	**24,2**	**26,6**		**9,49**	**11,16**	**4,9**	**8**

Figure 1 shows the distribution of Netspeak standards within the 1st and 7th semester. In the first semester, students used an average of 32.7% of Netspeak standards in the professor-student discussion and even 35.8% in the student-student discussion. At the final year of the study Netspeak standards amount is lower, but still a professor-student discussion include 24.2% of Netspeak standards and in the student-student discussion, there is 26.6% of it. Discussion professor-student is more formal; consequently, the amount of Netspeak standards in both years is lower than in the student-student discussion.

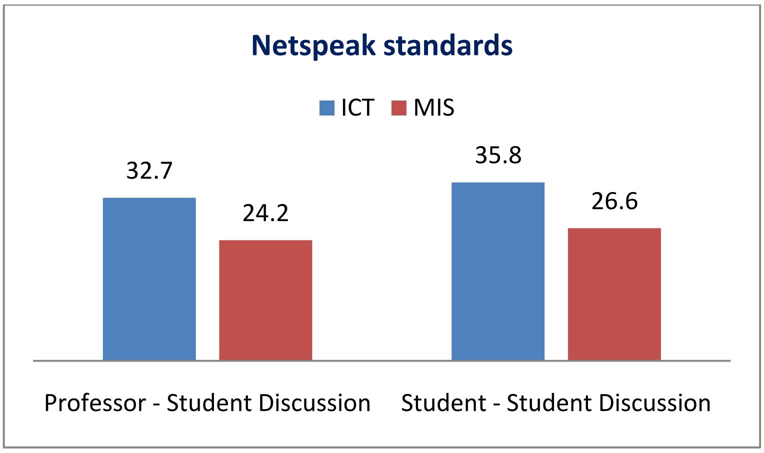

Figure 1. Netspeak standards distribution in 1st and 7th semester

Similar situation occurs when analyzing the density of the Netspeak standards by the number of characters. Netspeak density is higher in the discussion student-student, which is less formal. Also, density is lower in the 7th than in 1st semester.

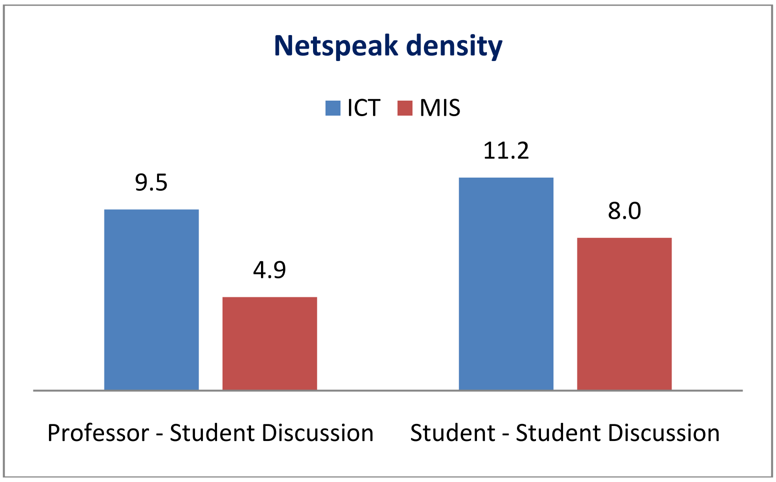

Figure 2. Netspeak density

Regarding the distribution of the standards within each group, in seventh semester there is an increasing numbers of standards in the ICT group as well as in the group Other. Notable decrease of the standards is noticed in the group Prosody compared with the number of standards in the first semester. (Figure 3 and 4)

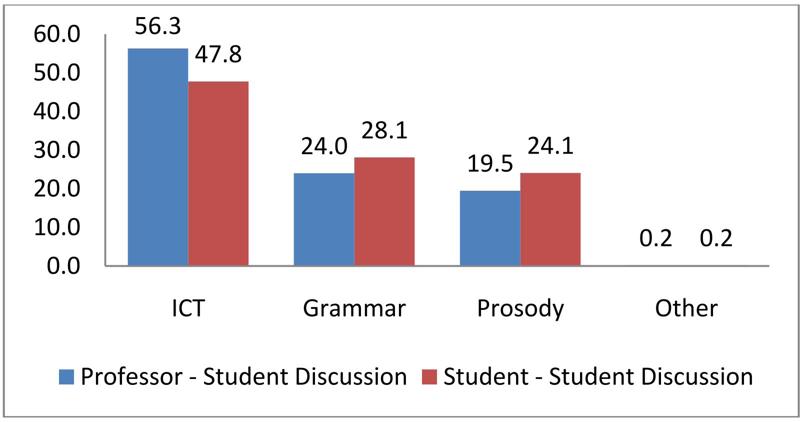

Figure 3. Distribution of standards (in %) within the groups – 1st semester

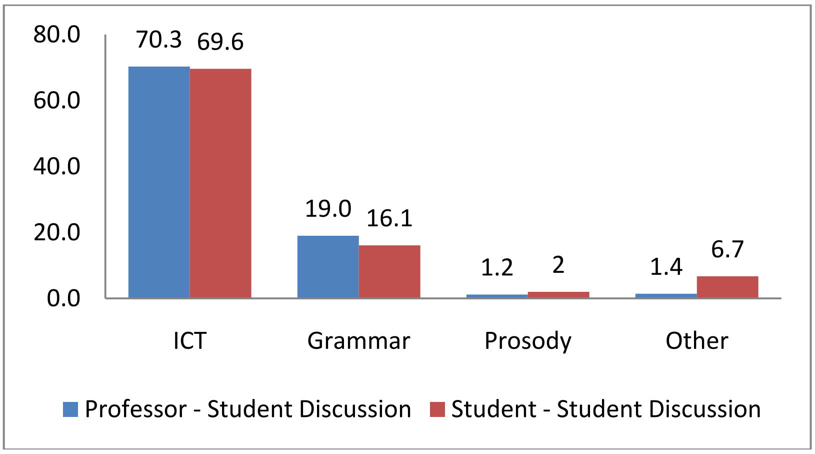

Figure 4. Distribution of standards (in %) within the groups – 7th semester

Since these courses are related to new technologies it is a logical high rate of standards that belong to the I1. Over 80% of students use a variety of English words in the first semester in both types of discussions. In seventh semester I1 varies between 86% in the professor-student discussions, and even 94% of the student-student discussion. Although the amount of Netspeak standards depends on the type of discussion, and of the number of characters, the character density analysis shows that there is a correlation between the use of Netspeak standards and the density of Netspeak standards / unit character.

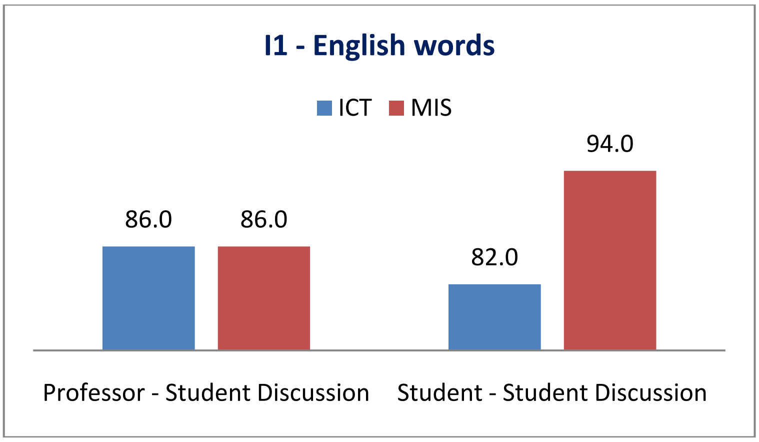

Figure 5. Standards distribution I1

It is interesting to analyze the standard I2 tied to acronyms and abbreviations (Figure 6). Standards differ in student-student discussion in the 1st semester. This might be explained by the significantly shorter discussions in relation to the discussion of professor-student.

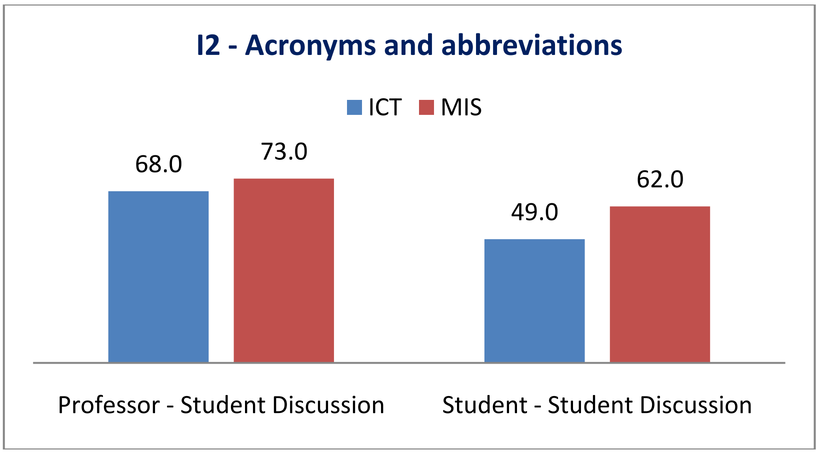

Figure 6. Standards distribution I2

Table 3 shows the less use of the standards G1 i G2 in 7th semester, while the standard G3 remains almost the same. In the first semester, students have used the LMS WebCT, and in the seventh Blackboard [14] which gives better support for the use of Croatian diacritics so this is one of the reasons why in the seventh semester students omit less diacritics than in the first semester.

A large drop of the standards P1, P2, P3 in the seventh semester is noticed, but generally remains somewhat larger quantity of standards in discussions in which students act as moderators, and in those which are less formal. If we analyze the density of Netspeak standards in the number of characters, the difference is even greater.

Given that these discussions are used for instructional purposes it is interesting to analyze the extent to which students use a salutation at the beginning (Figure 7) and complementary closing at the end of the post (Figure 8).

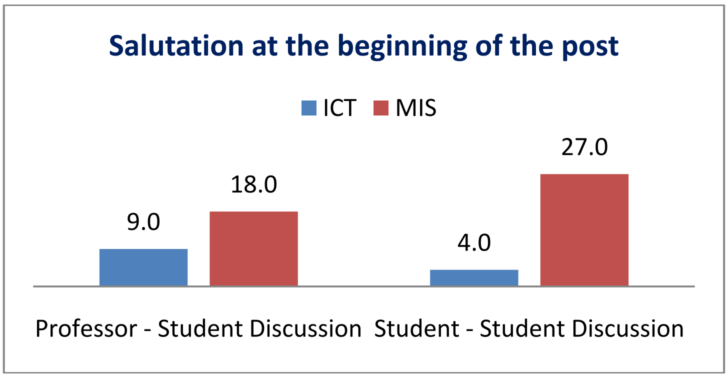

Figure 7. Salutation at the beginning of the post

Although each professor in the professor-student discussion begins and ends with greeting, only 9% of students use a greeting at the beginning of the discussion professor-student in 1st semester, and 18% in the 7th semester. As expected, students to a lesser extent use salutation at the beginning of the student-student discussion in 1st semester - only 4%. Unexpectedly, in the seventh semester, larger amount of students use salutation at the beginning of the student-student discussion, then in the professor-student discussion. Moderators influence the discussion. The discussion continues as a pattern set in the previous discussion.

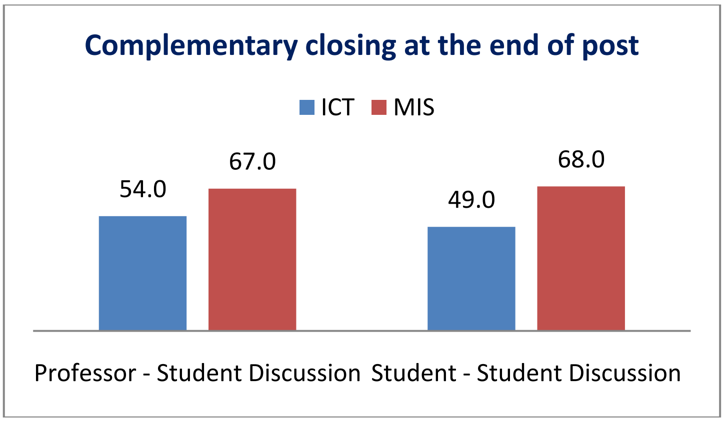

Figure 8. Complementary closing at the end of post

As expected, students use complementary closing more often in the seventh semester than in the first semester. It is very interesting to observe that over 50% of salutation belongs to the standards I2 and I3 – 32.6% are acronyms and 25.5% are emoticons.

4. Conclusion

Netspeak is a new language form originated from the development of the new media such as social networks, Skype, MSN, SMS etc.., and spread into the educational discourse. In this paper authors analyzed the quantity and density of Netspeak standards within the same generation of students – at the beginning of the study program in the first semester, and at the end of the study program in the seventh semester. Content analysis of closed asynchronous online discussion on ICT and MIS course taught at the Zagreb School of Economics and Management was conducted. Authors chose to conduct the analysis of the discussion made in the two courses that have the most dynamic discussion within the e-learning system. Both courses deal with new technologies so they can easily be compared.

Further steps to be undertaken within the project Netspeak are as follow:

- Measurement of the frequency of Netspeak standards and its density in different languages.
- Implementation on social media and other informal means of communication.
- Development of the applications for content analysis and measurement of the amount and density of the Netspeak standards, etc.

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An Exploratory Study of Lecturers' Perceptions on the Use of Mobile Wireless Technology to Improve Lecture Interactivity

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Abstract

The paper aims to explore lecturers' perceptions on current lecture interactivity and the use of Mobile Wireless Technology (MWT) to enhance interactivity between lecturers and students in higher learning institutions in Malaysia. A total of twenty-two lecturers from higher learning institutions located in urban areas were interviewed using semi-structured interview questions. Thematic analyses revealed four main themes: responsive students, interaction purposes, interaction techniques and interaction barriers. To be specific, findings showed that students who are academically good tend to be more responsive, the main purpose of interaction is to improve students' understanding of the subject matter, and question and answer sessions to be the most effective way to encourage students to be responsive in class. The majority of the lecturers also cited students' poor attitude as the biggest barrier in interactions during lectures. Finally, most lecturers perceived MWT can be used to overcome introversion, improve collaboration and real-time interaction. One interesting finding is the concern among the majority of the lecturers that the use of MWT may be disruptive during lectures. However, the overall results showed that the majority of the lecturers felt positively about the use of MWT to improve their interactivities with students during lectures.

Keywords: *Interaction, Mobile wireless technology, Response system, Student's attitude, Culture.*

1. Introduction

Students' learning is known to be improved when they are able to participate in class. They are also deemed to understand their lessons better when they engage actively with subject material, and also the instructor or educator. However, in-class interactions may not be conducive at times, especially when there are a large number of students. Some students also may not find it comfortable to pose questions during class. Thorough understanding on the importance of interactivity during lectures between students and lecturers and existing barriers preventing interaction are therefore vital. The use of mobile wireless technological (MWT) tools, such as a Response System (RS) is believed to be able to raise students' participations and engagements in class. In the higher education sectors, MWT have made its impact and is fast being utilized by students and lecturers. MWT's myriad advantages, such as mobility, simplicity, strategic deployment of services, speed, competitive pricing among competing brands, accessibility, ubiquity, etc. have resulted in it being a valuable tool in higher education [1].

Knowledge of MWT adoption intention can help higher learning institutions utilize MWT to assist lecturers to interact better with their students, and provide an avenue for students to interact with their lecturers during lectures. In Malaysia, most of the higher learning institutions are equipped with wireless connectivity to enhance students' learning experiences. However, the extent to which the wireless infrastructure is being utilized by the lecturers for education purposes is not known, particularly when it comes to interacting with the students. Therefore, the current study was undertaken to gather lecturers' perceptions on the importance of engaging in active interactions with their students during lectures, current approaches utilized to encourage students to provide feedback, and the obstacles they faced in their efforts to improve interactivity with their students during lectures. Additionally, the study also intends to examine if the lecturers are open to the idea of using MWT during lectures as a tool for enabling students to interact via sending text messages to the lecturer using any mobile devices. Semi-structured interviews were conducted among a group of lecturers from five higher learning institutions located in the urban areas as these institutions support 3G services, and hence are better equipped to support the use of MWT.

The remainder of the paper is structured as follows: The related work to the study is discussed in the next section, followed by the research methodology. The results and discussions are presented next, followed by the conclusion.

2. Related Work

Considerable amount of research studies have shown that the use of computers and technology is an integral part of the education process to improve learning [2] – [4]. Mixed findings have been reported on the use of MWT during lectures by researchers. Large number of students in a classroom hinders or limit interaction opportunities, and the use of MWT enable students to send their feedback to their teachers [5]. The use of mobile computers by students and lecturers during lectures has been proven to enhance interactivity and promote higher levels of learning attention [6]. Another study discovered that the use of wireless laptops enhanced interaction amongst students and between students and lecturers, though the authors concur that wireless laptops can be disruptive if they were not used for learning purposes [7].

A study of undergraduates' use of mobile notebooks for learning Java programming showed positive students' learning gains [8]. Similarly, researchers in [9] found personal digital assistant (PDA) coupled with an application that enabled students and the lecturer to interact yielded numerous benefits towards the teaching and learning processes, especially in enabling immediate interaction to take place amongst students and the lecturer. However, use of laptops during lectures resulted in students spending substantial amount of time multitasking and may negatively affect students' learning [10]. Disruptions from students' laptop activities for non-academic purposes, such as instant messaging, web surfing and playing games are some of the issues identified when laptops were allowed to be used during lectures, though benefits such as improved notes taking and students' collaboration were also observed [11] – [12].

The role of lecturers and students alike in integrating technological tools during lectures to promote active learning and interactivity is crucial. Lecturers who are adept at using technological tools and software were found to be more inclined in adopting and integrating technology in the classroom [13] – [14]. The same sentiment applies to students whereby familiarity with MWT results in them having an open mind towards using MWT for academic purposes [15] – [16]. On this premise therefore, higher learning institutions need to invest and provide adequate mobile support. However, additional hours required by lecturers for planning lessons that integrate these technological tools, and hardware and software constraints are two main adoption obstacles [13], [17]. In a comparative study of undergraduates' learning scores with similar academic credentials, students who used a specially designed software which allows lecturers to provide immediate responses to their questions showed higher learning scores than students who did not use it [18].

Due to its relatively light weight and ease of mobility, the proliferation of newer mobile devices such as tablet computers and iPad has brought significant changes in higher education. In an online survey by Pearson Foundation of 1,206 college students and 204 college-bound high school seniors in the United States, tablets ownership in college and college-bound students has tripled in just a year, and that 90% of the students who owned tablets viewed such devices as valuable for educational purposes [19]. Colleges and universities have begun experimentations integrating tablets and iPad in classrooms. Results from studies conducted from this initiative revealed students' preferences for using the iPad during classes to access learning materials [20]. Findings from three Indiana University on the effectiveness of iPad for teaching and learning discovered that despite the initial adjustment to such technology, benefits observed was greater students' engagement, collaboration and learning opportunities beyond the classroom [17].

3. Research Method

3.1. Respondents

The target respondents were lecturers with at least two years of working experience. Additionally, they were also sought based on their field of expertise, that is, science and non-science domains. This is because the need to use MWT may be more beneficial or easier for a science oriented subject compared to a non-science subject. A total of 22 lecturers (Males: 9; Females: 13) were interviewed, with the majority from the Information Technology Department (31.8%) followed by those from the Engineering (18.2%) and Management (18.2%) departments. The majority of the lecturers were between 30 – 39 years old (54.5%), followed by those between 40 – 49 years old (36.3%). Most of them also taught the undergraduate programmes (68.2%). Approximately 50% of the lecturers had more than ten years of teaching experiences, followed by those between six – ten years of experiences (40.9%).

3.2. Interviews

Face-to-face individual interviews were conducted to elicit the lecturers' perceptions on the use of MWT during lectures. The interviews were semi-structured in nature whereby a set of questions were prepared to guide the interviewer throughout the interview process. Demographic details were collected prior to posing the interview questions, such as respondents' age, years of working experience, subjects taught etc. These were then followed by the interview questions – examples include: "Do you currently use any MWT tools during lectures?", "Do you think interaction between students and lecturers are important during lectures?" and "Do you think lecturers should use MWT during lectures?", among others. Some of the questions were further probed based on the responses given. All the questions were open-ended. All the interviews were conducted in the respondents' offices as this ensured their comfortableness with the environment. The interview sessions were recorded and notes were also taken. Upon the completion of each session, the interviewer went through the discussions to clarify and to confirm the respondents' answers, suggestions and opinions. The entire process took approximately eight weeks to be completed.

4. Results and Discussion

In general, there were unanimous agreements from all the lecturers on the importance of interaction with the students during lectures. Thematic analyses revealed four main themes, namely, responsive students, interaction purposes, interaction techniques and interaction barriers.

4.1. Responsive students

When the lecturers were asked "*What type of students generally respond during lectures?*" most of them (12/22 - 40%) agreed that students who sit in the front rows and those who are diligent (11/22 - 36.7%) are most responsive during lectures (Figure 1).

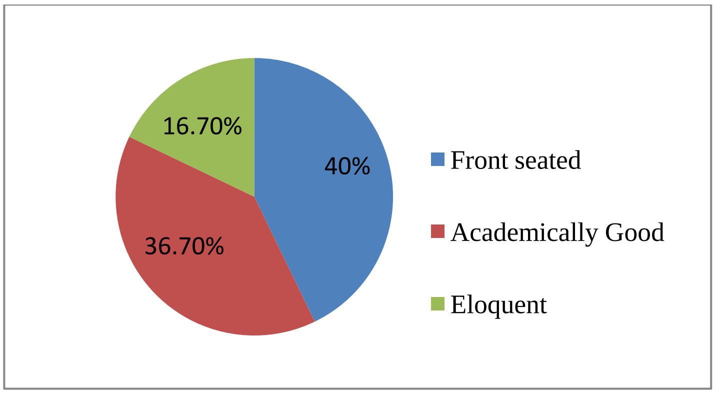

Figure 1. Responsive students

This is a common scenario in class or lecture rooms whereby students who are academically good usually are seated in the front rows, and are more responsive than those who sit at the back. Additionally, these students also tend to ask questions for clarifications during lectures. A small percentage of lecturers (16.7%) felt that students who frequently and actively engage in conversations amongst each other and with the lecturer tend to be more responsive. Other than being talkative, the language skill may also affect a student's responsiveness. For instance, a student who has a poor command of the English language probably will shy away from posing questions or interacting with the lecturer during class, resulting in a lack of understanding or poor grasp of the knowledge/lesson taught. This notion is also supported by other studies that reported lecturers or instructors often allow their less proficient students to remain silent or to participate less than their English-fluent peers [21].

4.2. Interaction purposes

An overwhelming 72.7% (16/22) of the lecturers perceived interaction during lectures to be crucial to ensure that students understand the subject (Figure 2).

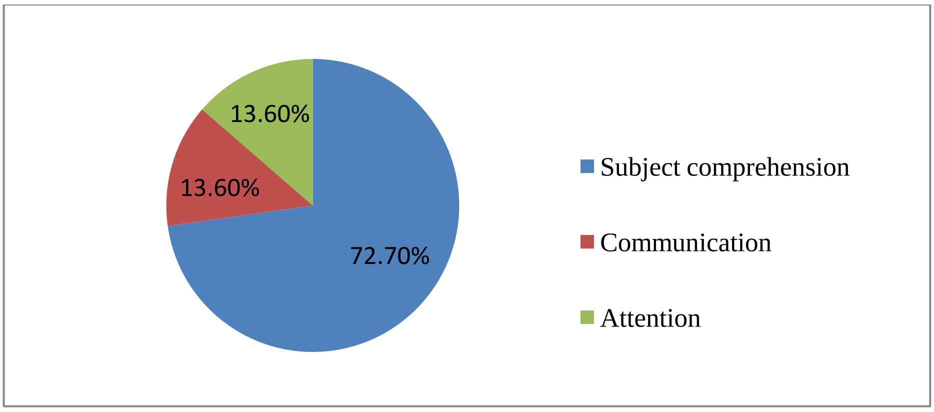

Figure 2. Interaction purposes

An equal percentage of the lecturers (13.6%) also felt that interaction during lectures is important to acquire students' feedback and to ensure that students are paying attention in class. Interaction between students and lecturer during lectures usually take place when the lecturers ask questions pertaining to the lesson covered for the day, or from the previous lessons. This practice enables the lecturer to somewhat gauge the students' level of understanding of the subject matter. Similarly, responsive students may also ask questions for clarification purposes during lectures. These findings are in-line with previous studies that have reported MWT tools to help students provide their feedback, enhance interactivity and promote learning attention [5] – [7].

4.3. Interaction techniques

When the lecturers were asked for the best interaction techniques, approximately 72% (15/22) of them mentioned that question and answer (Q&A) sessions were effective in eliciting responses from the students (Figure 3).

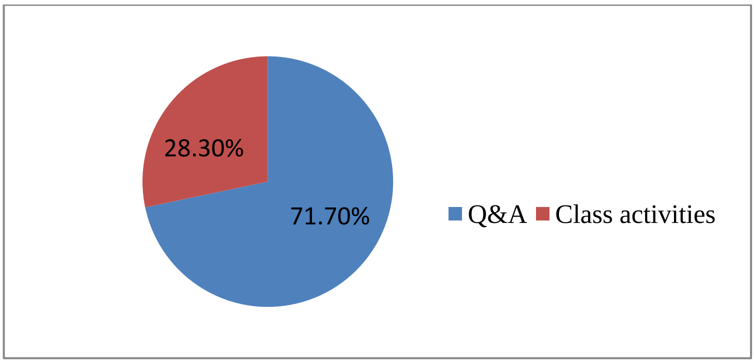

Figure 3. Interaction techniques

Questions were generally asked to develop students' interests in the subject matter, to assess students' level of understanding and also to review current or previous lessons, among others. Studies have showed that posing questions during lessons is more effective in producing achievement gains. Effective teaching also involves lecturers to encourage their students' participation in discussions, welcome their contributions, and to motivate them by such practices [20] – [21].

4.4. Interaction Barriers

Finally, as for interaction barriers, students' indifference attitude were cited as the main reason by the majority of the lecturers (15/22 – 39.5%) as depicted in Figure 4.

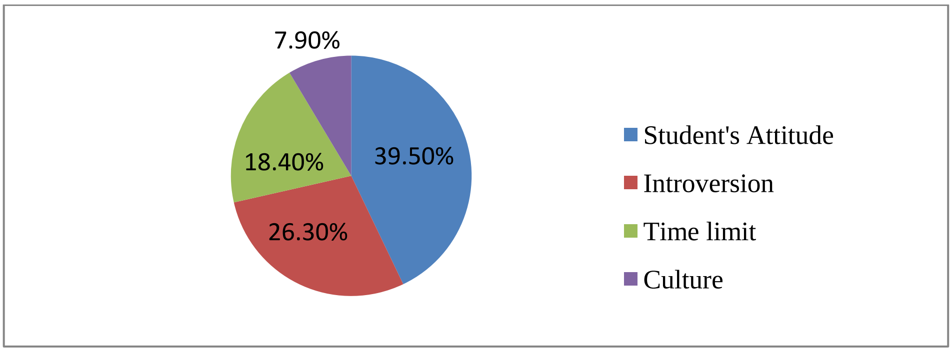

Figure 4. Interaction barriers

These attitudes include lack of preparation prior to attending a lecture, and lack of understanding on subject content, among others. When students do not have sufficient knowledge of the subject matter, they would not be confident and hence, shy away from responding to the lecturers during lectures. Most lecturers (26.3%) also mentioned introversion is probably also a reason for the lack of responsiveness among the students. Asians are generally introverted in the sense that they do not speak openly in public or are rather shy in voicing their opinions when surrounded by others. This is also applicable to the students whereby in a lecture room full of local and international students, the former tend to be more passive. This phenomenon is also observed among 7.9% of the lecturers who stated that culture may affect students-lecturer interactions during lectures.

4.5. Intention to use

On another note, the lecturers were also asked about their intentions to use MWT tools during lectures. Mixed findings were observed whereby lecturers who were open to the idea of using MWT during lectures were also concerned about the negative outcomes of such a move. On a positive note, most of them (34.8%) believed that MWT can be useful as a supporting tool (i.e. accessing academic related materials easily, etc.) and 30.4% agreed that MWT can be used effectively for real-time interaction. Almost 18% of the lecturers also felt that MWT is able to help students to overcome their shyness, lack of confidence, or language barriers.

However, most lecturers (52.8%) also voiced their concerns that MWT may result in students losing concentration during lecture. For example, students can be multi-tasking (i.e. chatting with their friends or families, updating their Facebook or Twitter, etc.) during the lectures, and it would be very difficult for the lecturer to monitor what the students are actually doing, particularly if the lecture size is big. Similar concerns were highlighted in other studies, such as [7], [11], [12]. Despite this, one cannot disregard the fact that MWT offers opportunities for student engagement during lectures.

5. Conclusion and Future Work

The current study employed a qualitative approach to investigate the possible use of MWT to enhance interactivity between students and lecturers during lectures in higher learning institutions. Through literature reviews [22], [23] and semi-structured interview sessions, evidence pointed to the lack of interaction between students and their lecturers in large lecture sessions, with most interactions taking place between lecturers and front-row seated students. This validates the problem statement of the research as an understanding of the current interactivity patterns in large lecture classes and the barriers preventing interaction was gained. Results showed the majority of the lecturers to be in favour of adopting MWT tools, despite some concerns regarding the negative effects of using MWT during lectures. Distraction to the lecture process was the most serious concern raised by the lecturers.

Findings from this study were obtained through qualitative method, i.e. semi-structure interview sessions limited to 22 respondents from higher learning institutions located in urban areas. Consequently, findings discussed in this study may not be representative of higher learning institutions in non-urban areas. Further studies will be conducted to validate the findings in order to make them more conclusive, and will employ quantitative methods via survey distribution to lecturers and students of higher learning institutions in urban and non-urban areas.

6. Acknowledgements

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Presenter: This paper is presented by Vimala Balakrishnan

Introducing an "Atomic" Curriculum Model for Information Technology Service Management (ITSM) Featuring Learning Objects and Vectors

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Abstract

This paper introduces the notion of a learning vector whose constituent components are the learning objects that derive from a multidisciplinary suite of learning areas. The proposition is that the learning vector is only properly established if all the learning objects have been activated. The learning areas are synonymous with the teaching input to the programme and are typically – ITSM knowledge, computer hardware and software knowledge, communication skills, business fundamentals and foundational mathematics. The skills performance bands, which graphically appear to be analogous to the valence bands of the Bohr model of the atom, represent – acquisition of foundational knowledge, practical skills through application, reflexivity through problem analysis, and professional skills through personal and strategic communication development. The nucleus of the model is composed of "prior knowledge" and "resources provision" representing the protons and neutrons of the system. This paper extends "A Collaborative University of Technology and Further Education and Training Curriculum Development Project" that was presented at the iNeer iCEER 2013 Conference in Marrakech, Morocco. The learning objects were identified as an outcome of the previous paper. The synthesis of the learning vectors was developed within an ad hoc curriculum workshop where members of the multidisciplinary team participated in creating and ratifying the content. It is conceivable that the refinement of the learning objects and vectors will be an ongoing endeavour.

Keywords: *IT Services Management, Curriculum Development*.

1. Introduction

This paper presents an innovative approach to teaching and learning practices at the Cape Peninsula University of Technology (CPUT) to deliver Information Technology Service Management (ITSM) practitioners to meet the needs of industry. It describes the CPUT vision for ITSM graduates and makes a proposal for implementing the study programme via its Higher Certificate curriculum. The paper seeks to clarify the instructional imperatives for efficacious programme design and delivery. It details the nature of the curriculum and the intended learning outcomes. The paper further provides insights into the pedagogical, technological, and operational dimensions for the program. This paper extends the paper - "A Collaborative University of Technology and Further Education and Training Curriculum Development Project" [1], presented at the International Engineering and Research held in Marrakesh, Morocco, 1 – 5 July 2013.

This paper introduces a novel way of representing curriculum intent on the basis of an "atomic" curriculum model. The atomic model in turn informs teaching and learning approaches to prepare students as future ITSM practitioners. The atomic model is described in terms of "learning objects" and "learning vectors". The learning objects are the topics, learning content and competencies that constitute the discrete learning outcomes. The ITSM curriculum draws from a wide range of academic disciplines,

including – information technology, business practice and communication development. The curriculum aims to expose students to foundational knowledge, applied competencies, reflexivity and professional development as the instructional levels of the ITSM discipline. The learning vectors are considered to be the constructive alignment of learning objects towards achieving holistic engagement and assimilation of the key performance aspects of ITSM practitioners.
The strategy to offer the Higher Certification in ITSM in collaboration with the Further Education and Training (FET) sector is explored.

2. The "Atomic" Nature of the curriculum

The atomic model is a tongue-in-cheek reference to the Bohr model of the atom. The relevant assumptions being that the atom consists of a nucleus and circular orbits and that electrons travel in the orbits around the nucleus. Furthermore, the further the electron is from the nucleus, the more energy it has and that only a limited number of orbits with certain energies are allowed. In other words, the orbits are quantized.

Figure 1 illustrates the "atomic" curriculum model based on the Bohr model of the atom. The nucleus symbolises the students' prior knowledge and the resources available to students as the "core" provision within the teaching and learning dynamic. The various instructional levels (or bands) of the programme are thought to be analogous to the orbits of the atom. The distance between the learning bands constitute the learning areas of the various subjects. Each subject consists of learning objects which are thought to be analogous to the electrons in orbit. The learning bands also represent the level of cognitive engagement of the learning object.

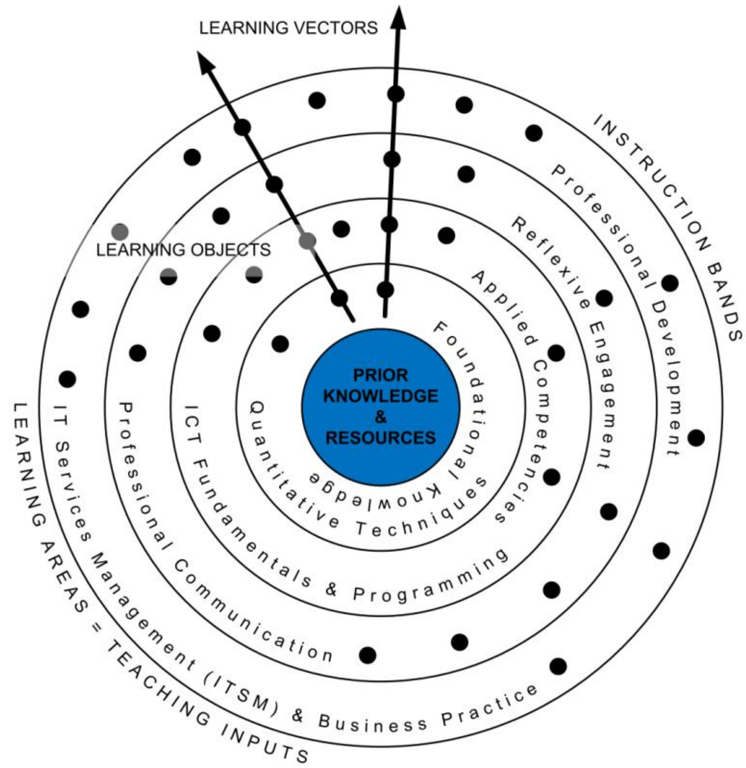

Figure 1. The "Atomic" Curriculum Model.

2.1. Learning Vectors and their Objects

In mathematics a vector is a quantity possessing both magnitude (size) and direction. A learning vector could therefore be defined as the magnitude and direction of learning. The alignment of learning objects creates a learning vector. In other words the learning gains magnitude and direction. The learning vector represents the constructive alignment of the program. The learning experiences within the course should be aligned so that a specific outcome can be achieved efficaciously. The learning vectors produce outcomes that prepare students to perform specific roles in the ITSM field.

Learning objects were developed for a specific purpose or situational performance intervention in practice towards defining the applied competencies of students. Learning objects were also included in the curriculum if they had foundational knowledge relevance. Similarly, learning objects would be included in the curriculum if it had relevance in promoting reflexivity and professional development. Learning objects might align to form learning vectors towards achieving specific learning outcomes. Learning object might feature in more than one learning vector but might in some cases not feature within any learning vector.

It is proposed that the "atomic" curriculum model will promote integration of curriculum content, constructively align teaching and learning approaches and potentially enhance the learning experience of students. The "atomic" curriculum approach demands careful consideration of the purpose for inclusion of specific learning objects in the curriculum.

3. Structuring the content

The learning areas (and teaching inputs, as illustrated in Figure 1) of the Higher Certificate in ITSM are presented as the highest level within the curriculum hierarchy. The next level of curriculum specification in the hierarchy is Subjects, as illustrated in Table 1.

Note: With reference to Table 1, "Computer Applications" can be referred to as "II-B". This notation will be extended to specify learning vectors towards achieving constructive curriculum alignment.

Table 1. Learning Areas and Subjects.

Learning Areas	**Subjects**
ICT Fundamentals (I)	Computer Networks (A)
	Computer Hardware (B)
Programming (II)	Computer Software (A)
	Computer Applications (B)
Quantitative Techniques (III)	Quantitative Techniques (A)
Business Practice (IV)	Business Practice (A)
Professional Communication (V)	Strategic Communication (A)
	Personal Communication (B)
ITSM (VI)	Information Technology Services Theory (A)
	Information Technology Services Practical (B)
	Information Technology Services Project (C)

Each subject is further detailed in terms of its topics, as is represented in Tables 2, 3, 4, 5 and 6.

3.1. ICT Fundamentals

ICT Fundamentals introduces the student to the computer, types of computer devices, its components and its connection to the network and internet. Students will work in groups to build and maintain computer related equipment, install patches and software.

Note: With reference to Table 2, "Connecting to a Network and the Internet" will now be referenced as "I-B-4".

Table 2. ICT Fundamentals Topics.

Topic s	Computer Networks (I-A)	Topic s	Computer Hardware (I-B)
1	Network Fundamentals and Technology	1	Introduction of the Computer
2	Standard Bodies and Network Models	2	Hardware
3	Network Protocols, Models and Standards	3	Software
4	Network Topologies	4	Connecting to a Network and the Internet
5	Design and Build a Small Network		

3.2. Programming

Programming is not a typical structured software development offering, but is intended to provide students with practical “hands-on” exposure to the “workings” of computer programmes. Students will be shown how to systematically “deconstruct” a suite of example software programmes; and then modify them. The course will demonstrate the “workings” of selected Excel VBA routines, JAVA desktop and web code, and Mobile applications. Students will be exposed to the programme design logic at a basic functional level. Students will be introduced to the concepts of software architecture, and object orientation and sequential programming approaches. Students will be shown how to open these applications and will be asked to make minor modifications to the code to affect various outcomes. Students will be supplied with the necessary “crib notes” to re-structure the software as required.

Table 3. Programming Topics.

Topics	Computer Software (II-A)	Topics	Computer Applications (II-B)
1	Programming Design Logic	1	Functional Design Logic
2	VBA Applications	2	Standard Application
3	JAVA Desktop Applications		
4	Mobile Applications		

3.3. Quantitative Techniques

Quantitative Techniques is intended to provide students with exposure to such quantitative techniques as required for solution to problems within the Higher Certificate. This is not intended to be a hierarchical course in mathematics but rather a refresher course in specific mathematical techniques in ICT. The coverage includes – basic arithmetic skills, Boolean algebra concepts, fundamentals of logic, fundamental concepts and skills of algebra, basic trigonometry and geometry, and fundamentals of statistics and probability. Most importantly, the course will provide treatment of the most common real-world mathematical challenges confronting (underprepared) students engaging in complex computer applications. This offering will use a Spreadsheet package (e.g. Microsoft Excel) to expose students to the mathematical manipulations required to solve problems relevant to the Higher Certificate programme. It is envisaged that students would become quite proficient in the Spreadsheet package as a “value add”.

Table 4. Quantitative Techniques Topics.

Topics	Quantitative Techniques (III-A)
1	Basic Computer Mathematics
2	Functions and Equations
3	Trigonometry and Geometry
4	Quantitative Techniques
5	Real-World Mathematics for Computer Applications

3.4. Business Practice

This offering is intended to provide students with exposure to the basic principles of business practice. The curriculum is designed to promote entrepreneurship, although many of our students will be employed in a corporate environment. The principles that students will be exposed to in the offering will apply equally to both contexts.

Table 5. Business Pracice Topics.

Topics	Business Practice (IV-A)
1	Information Technology Support Services
2	Economics, Politics and Social Philosophies
3	Business Practice
4	Business Accounting Practice

3.5. Professional Communication

Professional Communication is intended to provide students with the tools to apply the knowledge of the processes of communication in both personal and professional situations, to avoid communication barriers and to understand how verbal and non-verbal symbols are used to communicate. It also intends to provide students with the tools to promote self-image, self-awareness and cross-cultural awareness. The coverage includes concepts expanding on the interpersonal communication model, categories of communication, communication barriers, verbal and non-verbal codes, Maslow's hierarchy of needs, and frames of reference and intercultural communication.

Table 6. Professional Communication Topics.

Topics	Professional Communication (V-A)	Topics	Professional Communication (V-B)
1	Information Literacy and Basic Research Skills	1	Communication Concepts
2	Critical Thinking and Problem-Solving	2	Self-Image and Awareness
3	Academic Writing and Report Writing Skills	3	Intercultural Communication
4	Business Procedures		
5	Team Dynamics		
6	Mass Media, Social Media and Media Literacy		
7	Oral Presentation		

3.6. Information Technology Services Management (ITSM)

Information Technology Services Theory is designed to expose students to ICT Support Services. The course forms part of the Higher Certificate in ICT, focussing on entry-level user support knowledge, which will enhance the students' employability in the support industry. Information Technology Services Practical is designed to expose students to ICT Support Services. The course forms part of the Higher Certificate in ICT, focussing on entry-level user support knowledge, which will enhance the students' employability in the support industry. Information Technology Services Project is intended to provide students with an opportunity to integrate learning within the Higher Certificate programme. The offering is designed to afford students an opportunity to gain "real world" exposure to the IT Services industry and apply their academic knowledge. IT Services Project is focussed towards constructing a Portfolio of Evidence (paper-based or electronic), which will not only reflect work done at this level, but also serve as a device for recording professional exposure. Students will be exposed to Microsoft Project as a tool for generating the Project Management Plan. Students will be required to serve a two week period of internship in an IT Services environment and record their activities using the recommended SSASI (Swiss-South African Cooperation Initiative) approach.

Table 7. Information Technology Services Topics.

Topics	Information Technology Services Theory (VI-A)	Topics	Information Technology Services Practical (VI-B)	Topics	Information Technology Services Project (VI-C)
1	Introduction to Computer User Support	1	User Support Management and Product Evaluation	1	Service Desk
2	Customer Services Skills	2	Needs Analysis and Assessment	2	IT Services Project
3	Troubleshooting Skills for Computer Problems	3	Installing and Managing the Computers	3	Activities Logbook
4	Common Support Problems	4	Training Computer Users	4	Project Outputs and Outcomes
5	Incident Management	5	End-user Documentation		

4. Learning Vectors and ITSM Key Performance Areas

A number of key performance areas (KPA) or Exit Level Outcomes for ITSM practitioners have emerged from the curriculum development process, as detailed in Table 8.

Table 8. Higher Certificate in ITSM Exit Level Outcomes.

A qualifying learner will be able to:

- Communicate effectively with all role players within the IT Services Management industry sector,
- Understand the purpose and operational imperatives of IT Services Management as a sub-discipline,
- Understand the importance of ethical conduct within the IT Services Management industry sector,
- Solve problems and demonstrate competence in the application of IT Services Management concepts,
- Demonstrate basic project management competence,
- Collaborate in teams to accomplish a common goal by integrating personal and group communication strategies,
- Engage in a capstone project (independently or as part of a team) that demonstrates an understanding of the knowledge, techniques & skills of the IT Services Management sub-discipline,
- Identify the various types of end users and explore their possible needs in different IT support environments,
- Troubleshoot and maintain computer devices used by end users,
- Support end users in the use of existing standardised company software packages, and
- Manage the operational aspects of IT service centres in alignment with ICT policy.

It is essential that the each of the KPAs is supported in the curriculum and learning process by learning vectors constituted through the constructive alignment of specific learning objects.

We will consider here only one KPA or Exit Level Outcome to illustrate the deployment of the learning vector concept within the “atomic” curriculum model, namely - the “Troubleshoot and maintain computer devices used by end users” Exit Level Outcome. As is common in vocational curriculum development practice, we will furthermore consider the most common technical support issues.

Some of the known common technical support issues are – “Blue Screen of Death”, log-in problems, accidental deletion of files, computer running slowly, printer doesn’t work, internet is slow, USB not recognised, etc. We will consider here only “log-in problems” as an example of a common technical support issue.

The deployment of learning vectors to achieve efficacious outcomes in practice to resolve “log-in problems” is illustrated in Table 9:

Table 9. Learning Vector for “Log-in Problems”.

	Learning Objects					
Example of Common Technical Support Issue: “Log-in Problems”	ICT Fundamentals Learning Objects	Programming Learning Objects	Quantitative Techniques Learning Objects	Business Practice Learning Objects	Professional Communication Learning Objects	ITSM Learning Objects
Learning Vector	I-A-5	II-A-1	None	IV-A-1	V-A-1 V-A-2 V-A-4	VI-A-3 VI-A-4
Value Proposition	Understanding Security Architecture	None	Incident Reporting (Frequency Distribution)	Business Impact Study	Client engagement protocol	Resolve client issues

5. Discussion

The “atomic” curriculum model is presented in this paper as an innovative proposition for constructive curriculum alignment. It is proposed that the “atomic” model will promote integration of curriculum content, constructively align teaching and learning approaches and potentially enhance the learning experience of students. The “atomic” curriculum approach demands careful consideration of the purpose for inclusion of specific learning objects in the curriculum.

Integration of curriculum content is promoted through cooperative development. Instructional designers collaborate in the development of content for the different topics. When learning objects are developed, instructional designers must enlist a sort of “double vision” [3]. This entails conceptualising learning object content as part of whole, such as the entire certificate programme and as stand-alone content. Learning object content must be able to exist independently and yet collectively contribute to achieving the learning outcome or learning vector. A single learning object can contribute to the various learning vectors.

In order for learning to be effective there has to be constructive alignment. Constructive alignment is the matching up of the intended exit level outcomes to the needs of an industry. It also encompasses the manner in which learning facilitation takes place to achieve that goal as well as the alignment of the student’s interest and engagement in the subject content. This phenomenon of constructive alignment is referred to as the learning vector. This alignment of learning objects enables a student to solve a particular case in industry.

This approach can potentially enhance the learning experience of the students since “atomic curriculum” model starts with the recognition of the student’s prior learning. By recognising prior learning a meaningful learning experience can be designed. The student’s prior learning is represented by the nucleus of our version of the atomic model. The nucleus is our starting point in developing the necessary learning vector for the attainment of a particular exit level outcome towards the needs of industry. The learning vector comprises the alignment of learning objects. From a curricular perspective students are grown from their current knowledge set to a desired knowledge set. The current knowledge set is the prior learning and the desired knowledge set is professional practice. Students' knowledge is developed through the instructional bands. The instructional bands start with imparting foundational knowledge. The next band entails showing the students application. Thereafter students are engaged in reflective practice. Finally students are allowed to become professional practitioners. Along with the nucleus in the centre, the bands represented by rings our model looks similar to the Bohr Model of the atom, hence the "atomic curriculum model".

6. Conclusion

This paper provides the foundation for determining the learning required to address common incidents encountered within the ITSM field. A more detailed catalogue of the common incidents will contribute to determining the necessary education required at topic level. This will assist in developing objects that will allow Higher Certificate graduates to make a meaningful contribution within the workplace. It is evident that learning objects are the most meaningful and effective way of creating content for learning. Our interpretation of learning objects represents a departure from current arbitrary use of the term. A commonly accepted, accurate and functionally effective definition of a learning object is an immediate necessity. The first step in this direction, articulated in this paper, is to establish a concept of the learning object that clearly lays out the principle basis on which it is founded. Similarly, we suggest, there is a need to reengineer the design and development process of learning objects. In this regard the academics– involved in selecting the content should embrace a multidisciplinary and cooperative model of content development to select content that would meet the outcomes of the various learning vectors for the emergent ITSM industry.

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ICT in Technical Training to Address Unemployment in Kenya

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Abstract

Kenya like most developing countries, is struggling with the issues of youth unemployment. The yearly graduate output from the technical training institutions and universities have surpassed the number of jobs created per year in these countries. As a result, there is vast human resource whose contributions to the economy remain unutilized. Various stakeholders have blamed the education system in Kenya, arguing that it does not equip the learners with life skills and knowledge for self-dependency. That the system prepares a learner that has to rely on others for survival (i.e., employment). The major concern being that the graduates should create jobs at least for themselves. In this paper, we illustrate that to enrich the content of the education system to address this pertinent issue, information and communication technology (ICT) ought to be adopted. Such training approaches must prepare and equip the learners with the much needed skills to harness ICT to solve everyday challenges in their domains of specialization. We argue that Kenya is ready for the knowledge economy and information age, and therefore training geared for industrialization revolution may not be the tool (catalyst) to develop and provide employment to the youth. Further, we illustrate that the training must provide the students with the power to use our Kenya's indigenous knowledge and culture to address development issues in Kenya.

Keywords: *Indigenous knowledge, ICT, knowledge economy, information age, ICT4D, technical training.*

1. Introduction

Indigenous knowledge (IK) refers to ideas, beliefs, values, norms, and rituals, which are native to a local community, and are embedded in the minds of locals. According to [1], IK is an integral part of the development process of local communities; therefore it is the key to sustainable social and economic development for local communities. Anthropologists have discovered that the natives they study have found that they have cultures which they seek to express, conserve and develop to show their distinctiveness [2]. Indigenous knowledge is a profound, detailed and shared beliefs and rules with regards to the physical resource, social norms, health, ecosystem, culture, livelihood of the people who interact with environment both in rural and urban settings. It has been the basis for local level decision making in agriculture, health care, food preparation, education, natural resource management, and a host of other activities. It represents an important component of global knowledge [3]. In essence, IK is that knowledge used to run/manage all the sectors and sub-sectors of the traditional or local or rural economies/society [4]. Even at a time when all dimensions of live have adopted technology, the beauty and significance of African's indigenous knowledge is not something we can neglect particularly in meeting our daily challenges such as unemployment, health complications among others. Benefits of IK are endless as indicated by [1]:

- IK can provide problem-solving strategies for local communities, especially the poor;
- Learning from IK can improve understanding of local conditions;
- Understanding IK can increase responsiveness to clients;
- Building on local experiences, judgments and practices can increase the impact of a development program beyond cost-effective delivery of staples;

- Indigenous approaches to development can help to create a sense of ownership that may have a longer lasting impact on relations between the local population and the local administration, giving the former a means of monitoring the actions of the latter;
- IK can provide a building block for the empowerment of the poor.

The greatest concern, however, is how indigenous knowledge is rapidly disappearing. Indigenous knowledge is an implicit knowledge and can only be transferred from generations to generations through oral traditions and demonstration. It is critical to note that indigenous knowledge is usually stored in the minds of elderly people who may pass on almost too sooner thus, risking the chances that such knowledge may be lost since it was not documented [4].

Communication lies at the heart of every society. Communication with others does not only allow us to share knowledge, goods and to build our livelihoods but it also gives us the opportunity to express affection and emotions with our close ones [5]. ICT provides unique tools for supporting and encourage cultural diversity and to preserve and promote the language, distinct identities and traditional knowledge of indigenous peoples, nations and tribes in a manner which they determine best advances these goals [3]. ICT can be used to: capture, store and disseminate indigenous knowledge so that traditional knowledge is preserved for the future generation; promote cost-effective dissemination of indigenous knowledge; create easily accessible indigenous knowledge information systems; promote integration of indigenous knowledge into formal and non-formal training and education; and provide a platform for advocating for improved benefit from IK systems of the poor.

In this paper, we illustrate that to enrich the content of the education system to address unemployment, ICT ought to be incorporated. Such a training approach must prepare and equip the learners with the much needed skills to harness ICT to solve everyday challenges in their domains of specialization. We argue that Kenya is ready for the knowledge economy and information age, and therefore training geared for industrialization revolution may not be the tool (catalyst) to develop and provide employment to the youth. Further, we illustrate that the training must provide the students with the power to use our Kenya's indigenous knowledge and culture to address development issues in Kenya. The rest of this paper is organized as follows: Section 2 discusses the value of indigenous knowledge in developing nations; Section 3 evaluates the contribution of indigenous knowledge to sustainable development using ICT. Challenges in using indigenous knowledge to address current issues are presented in Section 4, while Section 5 provides an analysis of the role of ICT in technical training (education) in attempts to address unemployment. Section 6 discusses the role of ICT in incorporating indigenous knowledge in education while Section 7 concludes the paper.

2. The Value of Indigenous Knowledge in Developing Nation

Indigenous knowledge affects the well-being of the majority of people in developing countries. Some 80% of the world's population depends on indigenous knowledge to meet their medicinal needs, and at least 50% rely on indigenous knowledge for their food supplies. Because it is mostly stored in people's minds and passed on through generations by word of mouth rather than in written form, it is susceptible to rapid change [6]. At first glance, the relationship between indigenous knowledge and the Internet seems fraught. Indigenous knowledge provides a distinct set of beliefs, practices and representations avidly tied to place; the internet lauds itself for erasing boundaries and borders.

On one hand, the traditions encapsulated in indigenous knowledge are culturally unique, using local understanding to solve local problems. This makes it an important component in the fields of ecology, education, agriculture and health security. On the other hand, the internet is lauded for spreading information to help people, but it is also a bazaar, tilted towards large corporations and the economies of scale: Amazon.com, Google, Microsoft, and PayPal. Indigenous knowledge has certain spiritual and ceremonial components; the internet is largely agnostic, and makes a good deal of money peddling pornography.

For all their perceived differences, the indigenous knowledge and global knowledge systems have become much closer in the past decade. Indigenous knowledge practitioners have begun leveraging different media to exchange ideas and publicize traditional learning to the larger world. It is arguable that ICTs can be used as cheap methods to capture, store and disseminate various forms of indigenous knowledge for future generations. ICTs also increase access to indigenous knowledge systems, especially to schools, where this learning can be incorporated into classrooms. The objective of this research is to illustrate the contribution of indigenous knowledge in solving unemployment problem through ICT in developing nations.

The study on preservation of Aboriginal cultures by [7] reveals that communities are repositories of in-depth knowledge and expertise that members can harness using ICT to promote and preserve their cultures and languages. By extension primary roles for ICT ought to be the preservation and revitalization of cultures and languages, the incorporation and strengthening of cultural components in the way institutions are designed, function and deliver services and the building of community and cultural networks to promote cultural cohesion, connectedness and renewal amongst the local peoples. The virtual communication capabilities of ICT cannot only foster the on-going use of local languages; it also serves to bridge existing generational divides. Perhaps in communities which promote interaction between generations, learning can then become a two-way street; the younger generations can help to instil a sense of confidence in older generations around the uses of ICT.

3. Indigenous Knowledge for Sustainable Development through ICT

Indigenous knowledge is dynamic; at least it must be dynamic. It evolved from years of experience and trial-and-error problem solving by groups of people working in their environments drawing upon resources they have at hand. Vital information on health, child rearing, natural resource management is often encoded in unique forms such as proverbs, myths, rituals, and ceremonies but often shunned for modern scientific techniques and thoughts. Incorporating indigenous and scientific knowledge means integrating information collected from rural people with scientific and technological information. Institutions must find ways to process indigenous information in the same way as scientific information processed using information and communication technologies. Information and communication technologies play major roles in improving the availability of indigenous knowledge systems and enhancing its blending with the modern scientific and technical knowledge. ICTs include telecommunications technologies such as telephony, cable, satellite and radio, as well as digital technologies, such as computers, information networks and software. The new information and communications technologies such as computers and the Internet, can help generate wealth and jobs, build bridges between governments and citizens, forge relations among organizations and communities, and improve the delivery of essential services to poor people [3].

Unemployment is an emergent and a very severe issue Kenya. The education system in place has only worked to make the situation worse by neglecting the need to adapt its content to meet the requirements of information age and knowledge economy. It is a time that the education system has to get transformed to meet this need. Such a proposal is presented by [8] that considers an online model based on improvement quality education for all (IQEA) action research framework for school improvement. This model brings together the school-based cadres to share emerging issues, themes and evaluation and eventually develop expertise in managing change in their own institutions and beyond through the use of ICT.

While some people still remain skeptical about the direct contribution ICTs to indigenous knowledge transfer and poverty alleviation, there are signs that ICT's can contribute to development goals and to the exchange of indigenous knowledge. Proper application of ICTs requires understanding of the main characteristics of indigenous knowledge and defining tools, applications and services that meet those characteristics.[3]

4. Challenges in Using Indigenous Knowledge to Address 21st Century Issues

There is growing recognition of the importance and contribution of indigenous traditional knowledge to global society. IFLA (The International Federation of Library Associations and Institutions), for example, acknowledges the intrinsic value and importance of indigenous traditional knowledge and local community knowledge, and the need [9]:

- To recognize the significance, relevance, and value of indigenous traditional knowledge and local community knowledge, so that this knowledge is used when developing solutions to difficult modern issues and when planning and implementing projects.
- To protect indigenous traditional knowledge and local traditional knowledge for the benefit of indigenous peoples as well as for the benefit of the rest of the world. This knowledge is vulnerable, both because it is exploitable and has been exploited, and because of the loss of elders and the significant decline in emphasis on transmission of the knowledge to younger generations in the face of pressures for modernization.

The application of ICTs for managing knowledge is not without problems. Not all aspects of living traditions of indigenous knowledge can be captured as 'artefacts' using digital technology. The collection of information from diverse indigenous sources is often a laborious, time-consuming and costly process. Those with knowledge may not be willing to share their actual knowledge. Efforts to capture indigenous knowledge by ICTs and setting up databases were not successful as hoped due to inadequate frameworks for capturing and making the knowledge available in usable formats to the people who need them and who often do not have access to ICTs [3].

Intellectual property right issues are other challenges, particularly if indigenous knowledge leads to profit for transnational corporations. Documenting and publicizing IK could immediately lead to their appropriation by others without return to innovators. The intellectual property rights of the individuals and communities have to be protected and benefits have to be generated for the innovators as well as local communities. Community structures such as tele-centers are increasingly becoming as the most important platforms for capturing, transfer and exchange of indigenous knowledge [1]. Other challenges in suing indigenous technical knowledge include [10, 11]:

- Lack of standardization and documentation of indigenous technologies and practices;
- Education and exposure especially of the young generation to modern training have biased people's attitudes towards using indigenous technical knowledge;
- Some religious beliefs do not encourage indigenous beliefs and technologies regarding them as demonic and superstitious;
- The educated people despise some indigenous methods referring to it as ineffective and dirty;
- Selfishness that inhibits people from passing on knowledge to others;
- Depletion of most trees and herbs that are sources of local medicine;
- Variation in prescription such as quantity to administer at a time and for how long

As stated above, ICTs provide a perfect example for integrating indigenous knowledge into both formal and informal education systems. Technology could facilitate disseminating ideas about local cultures to students and provide schools the possibility to teach some curriculum in a local language. In technical training (offering certificates and diplomas), does increasing access to traditional knowledge give it more credibility in the eyes' of students? What balance do we need to establish between the tradition and modernity? And what is the role of traditional knowledge in addressing developing nations' issues such as unemployment? These questions are addressed in the subsequent sections.

5. Adopting of ICT in Technical Training and Education to Address Unemployment

Marshall et.al in [8] explores the factors influencing the digital divide in four schools. Learners' ICT competence was compared between and across schools in relation to gender, home access and home language in addition to support and training possibilities for the teachers. The main findings indicate that, despite substantial efforts by educational authorities to increase ICT access for learners and teachers in public schools in Cape Town, when learners' ICT competence is compared, digital equity has not been reached. In order to increase digital equity and decrease the digital divide, a renewed policy focus is needed which puts greater emphasis on addressing the severe inequalities of the learners within their school environment as well as outside of school, taking their home situation into consideration to a greater extent [12].

There are some rich case studies that illustrate how schools have integrated ICT into their practices, which have relevance to improving learning for such students in specific contexts [13]. In this study by [13], it is reported that both teachers and parents agreed that ICT did the following when underpinned by innovative teaching:

- Motivated and stimulated learners;
- Solved some problems of students' 'motivation' for academic work and competence with literacy;
- Encouraged problem solving, analytical and creative thinking;
- Improved students' understandings, assimilation and creation of new knowledge;
- Provided new modes of communication to network locally and globally;
- Provided access to data bases, websites and discussions that were previously unavailable;
- Assisted in the development of independent learning and research skills; and
- Reduced failure for at risk students.

This finding is similar to that in [13] that reported that ICT can assist in social development and can lead to the new skills necessary for a knowledge society such as digital or network literacy. ICT can also improve subject learning and vocational training. Moreover, [14] indicates that the full integration of ICT into technology rich classrooms changes the nature of teaching and learning, creates more independent and self-motivating learners, encourages the use of multiple teaching methods, and encourages team oriented inquiry. In general, the effects for students as perceived by teachers has been largely social and psychological in terms of changes in attitude and increased engagement and study habits. There is a weaker untested association between cognitive learning outcomes and ICT use [13].

Even in attempts to address education (and training) needs using ICT to address the need of unemployment, the following bottlenecks have impeded realization of this goal [13]: Technology poor schools tend to be located in communities with inadequate communication infrastructure including small bandwidth, under resourced libraries, few Internet cafes, and even fewer ICT employment possibilities. The future digital divide, once access is universal, will be based on whether students have thick or thin access. Systemically, there is a lack of coherent infrastructure policies or negotiations with telecommunication providers to supply access to low income families, low socio-economic and rural schools at lower costs resulting in narrow bandwidths and overall lack of regional infrastructure and employment in ICT. Schools, particularly those that are disadvantaged, place greater demands on teachers, who find it difficult to sustain innovation due to the overload of responsibility and lack of long term funding. ICT policies and teacher professional development have not made issues of individual difference and equity which is integral to successful use of ICT. The weakest area of teacher pedagogy is in the area of possessing a repertoire of skills that deal with individual difference and learning styles. The focus of implementation of ICT policies and teacher professional development has been on the operational dimension (administration, access, resources, technical support), and not the cultural dimensions (gender dynamics in the classroom, control in the classroom, pedagogies), or the critical dimensions (values and attitudes) [15]. The cultural and critical dimensions of ICT are critical for teachers capacity to develop inclusive pedagogies, curriculum and assessment practices. Teachers have not been encouraged to take risks or rewarded for innovation. Teacher professional development, both pre-service and in-service, has relied heavily on the care rather than courage approach, by adding ICT as another possible tool rather than integrating it into classroom practice in ways that transform the classroom. A major area for further development for teachers is how to make decisions about which technology to use for what students, how to do it, and how to judge the effectiveness of its use. Teachers have little time available for collaborative work or planning, or even professional development in ICT. Teachers are anxious about using ICT because of its fragility—the unpredictability and insecurity arising from technical problems. As yet ICT is not part of the daily habits of most teachers

6. Using ICT to place Indigenous Knowledge Systems at the Heart of Education for Sustainable Development

A wealth of knowledge is already available within the developing world, particularly with regard to health and agriculture, two spheres of great impact on their populations. This knowledge is by definition, culturally sensitive and context-specific. It needs to be acknowledged, validated, reinforced, disseminated, innovated upon and preserved through practice. A bottom-up approach may provide a more realistic opportunity to capture the ideals of people-centred, need-based sustainable development. Placing indigenous knowledge at the heart of Education of Sustainable Development raises the critical issue of 'ownership' of knowledge. Existing patent laws are clearly biased towards western methods of knowing [9].

In addressing unemployment issues in developing nation, the technical training and education need to blend itself with indigenous knowledge. The skills acquired by the graduates should be all inclusive therein considering implicit and explicit knowledge. Consider, for instance, a diploma student training in fine arts. Further, let's imagine the student is training at Gusii Institute of Technical in Kisii County, Kenya. Kisii community in Kenya is well known all over the world for soap stone carvings and ceramics. The knowledge of soap stone carving is in fact an indigenous knowledge in this community, however due to poor preservation of indigenous knowledge aforementioned, the learner may not appreciate how the technical knowledge at the institute blends with local indigenous knowledge. The role of ICT is to preserve and avail this indigenous knowledge to the learners. While the role of the trainer is to assist the student understand how to merge both the indigenous knowledge and the technical knowledge acquired at the institute. The student is therefore able to acquire an all rounded skill that is applicable to the current trend in interior house and home decoration. In fact through ICT, the student has a command of large market niche that is only unique to his/her creativity. The Internet allows for an increasing visibility of local artists and opens new markets for cultural products. ICT have already been introduced into traditional Local artistic expressions with great success. For example, technology plays a critical role in the visual arts [16]. While much of the focus of technology is on the new industry, ICT can strengthen traditional local economies by expanding markets in areas such as tourism and the craft industries. The challenge, though, is finding a balance between the promotion of traditional ways of life in a culturally-sensitive manner and the commercialization of culture [7].

Experience of knowledge for development initiatives has shown that a vast array of tools can be used to facilitate the sharing of knowledge. Mechanisms such as community of practice, peer assists, synchronous and asynchronous communications are important to improve the exchange of indigenous knowledge. ICT tools such as intranets, search engines, content management systems (CMSs), electronic publishing systems, workflow systems, groupware, help desk applications, as well as more fundamental systems such as personal and group filing, project archiving have been refined to foster the sharing of knowledge [3, 7]. Specifically, sharing knowledge using these tools is possible but that does not always translate into action for taking decisions and modifying behaviors in order to achieve development goals.

But what does the integration of technology and learning mean for Local learners? First of all, ICT tools can be used to integrate culture and learning in ways that are much more conducive and culturally appropriate for local learners, possibly ensuring a more holistic experience akin to what local learners received in the past. In keeping with the notion of "cultural match," there is a growing body of evidence showing strong linkages between culture and learning and successful learning outcomes. While the technology and skills needed to use it are for the most part homogeneous, they can be adapted and used to incorporate the way that local peoples see the world and the way that they learn, and to create culturally-appropriate learning environments (including learning in one's own language). These examples underscore the importance of a school curriculum that is culturally and linguistically appropriate, especially in places where local culture is overshadowed [7].

7. Recommendations and the Way Forward

Governments have a role to encourage establishing policy structures that will enable indigenous peoples, working in partnership with ministries of education and universities, to develop their own approaches to use ICTs to provide culturally-responsive learning opportunities for their children. By doing so, they will help the indigenous peoples in their countries to fully participate in knowledge societies. The following recommendations are offered to help governments to review legacy educational policies that may need to be replaced and to consider the development of new policies to address the educational needs of indigenous peoples [9]:

- Provide a policy framework that enables indigenous communities to have control of their schools
- Establish national e-strategies to ensure full inclusion of indigenous peoples in the
- Knowledge Society
- Expand wireless capacity to provide access to indigenous communities and schools in remote areas
- Develop schools as community centres to provide access to ICT resources
- Develop policies to support the development of high quality content that is relevant to the cultures and languages of indigenous peoples, including non-literate persons
- Encourage and fund research in use of ICTs to support culturally based education
- Develop national policies and laws to ensure libraries, archives, museums, and other cultural institutions partner with indigenous communities in supporting access to and development of local content and cultural resources
- Develop educator professional development programmes designed to help non-indigenous educators to understand and support the culture of the indigenous community and the ways that ICTs may support access to indigenous content, expertise, and cultural resources
- Develop online educator development programmes to prepare indigenous peoples to become teachers
- Foster transnational collaborative efforts to develop culturally relevant learning resources and to exchange knowledge, experience, and best practices for use of ICTs to support the education of indigenous peoples
- Develop policies to use ICTs to provide continuous and adult education, retraining, life-long learning, and distance learning
- Support projects combining the use of traditional media and new technologies to support the use of local languages and culture and as a means to reach rural and isolated indigenous communities

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Social Impact of Technology-driven Education

Toward a Socially Relevant Policy Informatics Curriculum

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Abstract

All organizations are confronted with vast quantities of data and information that must be processed to make the most effective decisions. Decision-making is constrained by the policies regulating the organization. Policy informatics focuses on the use of computational methods to process this data and information, develop knowledge constructs and assist in the decision making process. The problem addressed is how to best prepare analysts working in developing countries to use computational methods to assist decision makers. This study starts with the assumption there is a need to use informatics to address public policy from a people-centered perspective. This research effort uses historical materialism to establish the curriculum content needed to best prepare students to use informatics to address public policy. The result is a four-year Bachelor of Science curriculum designed to prepare students with a socio-economic understanding of their milieu, ethical grounding and critical thinking skills. This curriculum also provides the computational skills needed to assist in policy development, analysis and decision-making. The paper ends with recommendations on how to implement this curriculum at Howard University and the National University of Science and Technology (NUST) in Zimbabwe.

Keywords: *public policy, informatics*

1. Introduction

Information systems and information technology (IS/IT) are playing an increasingly significant role in shaping organizational strategy. All organizations are confronted with vast quantities of data and information that must be processed to make the most effective decisions. Policy informatics focuses on the use of computational methods to process this data and information, develop knowledge constructs and assist in the decision making process. Decision makers must have a better understanding of the computational options available to assist in establishing policy and making decisions. With an understanding of information systems, operations research and decision science, they are better prepared to analyze, implement and evaluate policies.

Information systems specialists need to know the fundamentals of policy analysis, design, implementation and evaluation. They also need to understand the relationship between policy and politics and the policy process. This requires information systems specialists, engaged in policy work to have some background in political economy, development studies and public policy.

All stakeholders engaged in policy shaping should have an understanding of the social implications of different policy options. Public policies should be designed to empower people and improve the quality of life of the broadest population. Policy analysts must have a humanist ethical grounding and critical thinking skills. This requires a curriculum that provides students with a socio-economic understanding of their milieu. The curriculum must also provide the computational skills to address all aspects of the policy process. The next sections of this paper give an overview of public policy and informatics as distinct disciplines and covers curriculum related issues.

Historical materialism is the methodology used to examine the conditions surrounding policy formation and implementation. This examination helps identify subject matter included in a people-centered policy informatics curriculum. Earlier work on socially relevant computing provides the groundwork for this effort. The curriculum development focuses on a four-year Bachelor of Science program designed for underdeveloped and developing countries based on experience in Rwanda, Zimbabwe and South Africa. The primary use of the curriculum would be to produce graduates who have a grasp of the complexity of the public policy arena and a strong set of computational skills. This effort builds on earlier efforts on policy informatics and e-governance. [1][2] It also builds on previous work by the authors on appropriate technology, intelligent systems and simulation. [3] A unique feature of this effort is the focus on policy for African development and the use of historical materialism to shape the socially relevant context in which this curriculum is placed.

2. Public Policy

Public policy is concerned with policy set by governmental entities to direct and constrain not only government entities but also non-governmental organizations (NGOs) and profit centered entities such as multi-national corporations (MNCs). Public policy is also concerned with international collaboration, cooperation and standards that impact resources and concerns shared by multiple countries and regions. National policies on minimum wage, minimum working age, working hours, social security, and income taxes all play a role in determining a family's ability to engage in and gain from the work process. Health care policies from primary and secondary care to health insurance impact the real disposable income of families and more importantly their quality of life. Educational policies at the primary, secondary and tertiary levels have played a role in partially leveling the playing field for a broader population that has less wealth, skills and income.

The pressure from labor and communities has led to governments enacting public policies that create new and expand existing services. This has been an important aspect in the ongoing changes in the service sector.

> "Our proposition is that in developed countries in socially important areas like health, education, welfare, and security (HEWS), where there exists differential information in favour of the producer, responsibility for progress is necessarily on the agenda of government, in the public domain, and the service delivery activities of the professional specialists in these areas is properly structured not by the market system, but by institutions of social responsibility, like legal regulations, civil law, and a rigorously grounded, well understood and properly enforced code of professional ethics."[4]

It has been recognized that government has a particularly critical role in setting policy in developing countries. Any comprehensive national development strategy requires policies that promote expansion of infrastructures such as power, water, and road systems, as well as key industries and agriculture. Underdeveloped countries cannot wait for market structures to evolve to facilitate growth. A drastic transformation in infrastructure, industry and agriculture requires aggressive policies that align human, natural and capital resources that speed the development of infrastructure, industry and agriculture.

Dunleavy et al [5] argues that public administration and management has lost sight of the fact "that bureaucracies are socio-technical systems; and that the organization of information-processing is key to bureaucratization pushing ahead (for better or worse) the modernization and rationalization of human conduct." If government can overcome this short sightedness it will establish policies that promote this aggressive transformation of infrastructure, industry and agriculture, as well as government itself. Without such policies, development will be left to the unregulated market system. Under these circumstances, the most powerful enterprises and individuals will direct the development of information processing and innovation in general for their self-interest.

The public sector must learn from the best practices of the leading innovators in the private sector. These innovators pay close attention to customers' experiences and perception. West [6] highlights five keys to effective innovation.

> "First, successful adopters must devote sufficient resources to the innovation process … Second, successful innovators focus on the customer, value market research, and take visitor feedback seriously. … Third, technology innovators provide incentives for management and design teams to work together. … Fourth, innovators devote time to understanding their competition and determining how to position themselves vis-à-vis market competitors. … Finally, successful innovators tie resource allocation to customer satisfaction. Ultimately, there must be clear consequences that result from effective or ineffective technology innovation."

"The starting point (of the field of public policy) is Harold Lasswell, who laid down a grand vision of what he called the 'policy sciences' in the middle years of the 20th century."[7] According to Lasswell, policy science has the following distinguishing characteristics. It is problem oriented, multidisciplinary, methodologically and theoretically sophisticated and value oriented. "Public policy, then, was the response to the most important choices faced by government. The policy sciences would be the discipline that developed to clarify and inform those choices, and to assess their ultimate impact."[7] The different fields of policy study have roots in different older established disciplines. Today, these disciplines – political science, economics, public administration, sociology, philosophy, political economy and management contribute to the multidisciplinary nature of public policy studies. Also, different fields rely on different conceptual frameworks and different methodological approaches. A summary of what is involved in the various subfields of policy studies is captured in Table 1.

Table 1 Fields of Policy Study (adapted from [7])

Field of policy study	**Representative Research questions**	**Representative Conceptual frame**	**Methodological approach, examples**	**Representative Disciplines**
Policy and politics	Does politics cause policy, or policy cause politics	Policy typologies Stages Heuristic	Classification (typology and taxonomy) statistical analysis Case studies	Political Science
Policy process	Why does government pay attention to certain problems? Why does policy change?	Bounded Rationality Punctuated equilibrium Diffusion theory Systems theory Advocacy coalitions	Quantitative	Political Science Economics
Policy analysis	What should we do? What options exist to address particular problems? What policy option should be chosen?	Welfare economics Utilitarianism	Quantitative Formal/Qualitative Cost-benefit analysis Risk assessment Delphi technique	Political science Economics Public administration Policy subfields such as health & education
Policy evaluation	What have we done? What impact did particular program or policy have	Program theory Research design frameworks	Quantitative Qualitative Statistics Expert judgement	Political science Economics Public administration Policy evaluation
Policy design	How do people perceive problems and policies? How do policies distribute power and why? Whose values are represented by policy? How does policy socially construct particular groups?	Discourse theory Hermeneutics	Qualitative Text analysis	Political Science Philosophy/theory Sociology
Policymakers and policy making institutions	Who makes policy decisions? How do policymakers decide what to do? Why do they make the decisions they do?	Public rationality Ad hoc	Quantitative analysis Qualitative analysis	Political science Economics Public administration Policy-specific subfields
Policy Implementation	Why did a policy fail (or succeed)? How was a policy decision translated into action?	Bounded rationality Ad hoc	Quantitative analysis Qualitative analysis	Political Science Economics Public Administration Policy subfields

Effective public policy analysis and implementation is context dependent. Developing and underdeveloped countries in Africa and the global south must consider their particular milieu when investigating and selecting public policies. The use of informatics techniques can provide a clearer understanding of the impacts of different policy scenarios. However, in the past quite often informatics techniques have been used to justify expensive and extensive policies that have only brought debt and underdevelopment. [8]

In the global context, tax policies, government regulations on access to land, water and energy as well as wage and employment policies play a significant role in attracting or discouraging foreign investments. Underdeveloped countries should have unique concerns with regard to public policy. This makes it even more important that training in informatics prepares citizens dedicated to using information technology and information systems to provide the most thorough analysis of policy options.

Policy options should be selected that provide the highest level of empowerment to the broadest population in a sustainable fashion. This requires that the informatics techniques be used with a clear understanding of the national political economy and its global context.

3. Computing and Informatics

Some use the term informatics interchangeably with computing and computer science. There is a distinction. Informatics draws on computer science, cognitive science, decision science, operations research and information science to study the behavior, structure and interactions of the computational character of real and proposed systems. Some consider the central focus of Informatics "the transformation of information – whether by computation or communication, whether by organisms or artifacts. Understanding informational phenomena – such as computation, cognition, and communication – enables technological advances." [9] Informatics also involves the handling of data and knowledge. Data mining and knowledge acquisition are also important aspects of informatics.

Informatics is an applied discipline. With the increased power and utilization of computing, most institutions, organizations and infrastructures have computational components. The research and practice of informatics improves the proficiency of these computational components. These components then increase the performance of the associated institutions, organizations and infrastructures. Therefore, as a discipline of study,

> "Informatics brings the computational sciences together with the arts, the humanities, and the biological, health, information, natural, and social sciences in an interdisciplinary effort to solve problems. It uses algorithmic techniques and the power of computing to acquire and manipulate data, extract new knowledge, and ultimately examine existing and new problems from broad perspectives. The informatics major combines fundamental and practical computing knowledge with a choice of cognate areas from the liberal arts and sciences, providing students with the necessary background and specialized skills to work at the interface of computing and another discipline." [10]

One can view informatics as encompassing cognitive science, computer science and artificial intelligence. Cognitive science focuses on the study of natural systems. Computer science covers the analysis of computation and the design and evaluation of computing systems. Artificial intelligence plays a connecting role using computation and designing systems based on nature and human performance. "Informatics also informs and is informed by other disciplines, such as Mathematics, Electronics, Biology, Linguistics and Psychology. Consequently, Informatics provides a link between disciplines with their own methodologies and perspectives and brings together a common scientific paradigm."[9] The use of techniques to emulate and simulate the dynamic operation of systems is part of the repertoire of computational science that has proved a useful component of informatics in a variety of situations. Two important computational science techniques are discrete simulation and system dynamics.

3.1 Discrete Simulation

Discrete (computer based) modelling and simulation is a standard component of Mathematics, Engineering and Computer Science curriculum [11]. A wide range of information collected related to policy evaluation can be converted into probability distributions. The probability distributions can be used to conduct event driven stochastic simulations. These computer simulations are useful in projecting possible outcomes. The availability of low cost high performance computing makes possible the simulation of complex models. Multiple runs of the simulation are used to conduct statistical analysis. This provides useful quantitative information on the possible outcomes of various policies. Data such as arrival times and service times of customers can be collected from existing Post offices. This data can be fitted to distribution functions. A computer model can be developed reflecting a policy to expand postal services. After multiple runs a statistical report can be generated providing confidence intervals for key output variables. This can be done with different computer models reflecting alternative policies. This can lead to a quantifiable comparison of policy alternatives.

3.2 System dynamics

System dynamics is built upon the mathematics of differential equations. The causal relationships in a real or hypothetical system are quantified to reflect a set of differential equations [12]. System dynamics development systems such as Stella and Vensim greatly simplifies this development process allowing the user to focus on the feedback loops identified as being critical to the operation of the system. Critical to the implementation of the system dynamics approach is the identification of key variables and the patterns the values of these variables create over time [13] [14]. The computer uses numerical analysis techniques and difference equations to approximate the results of a set of differential equations. The simulation time frame spans past time periods as well as the future. The results of these simulation models are compared with the historical values of the key variables as a check on model validity. This system dynamics approach has proven useful in the study of a number of global and environmental systems [15][16]. Models simulating current policies can provide insight on the future impact of these policies. Scenarios can be developed with alternative policies. Simulations can forecast the impact of these alternative scenarios providing policy makers with quantitative support for particular policies. Extensive work on developing system dynamic models of the economy has led to the belief that "System dynamics modelling has a major future opportunity in developing policies and designing economic structures for better behaviour." [17]

4. Methodology

Historical materialism is the application of dialectical materialism to the historical development of socio-economic political society [18]. It allows one to make the clear distinction between different modes of production. In particular, there are distinctions between communalism, slavery, feudalism and capitalism. In each case the mode of production involves 'forces of production' and 'relations of production'. The forces of production are the people involved in production, their skills, their tools and the machinery they use in the production process. The relations of production address the ownership and control over the tools and machinery, land and raw materials involved in the production process.

Since, these relations of production focus on ownership and control, they position people in distinct classes. Under slavery the primary classes were slave owners and slaves. Under capitalism the primary classes are capitalists and workers. The tension between forces of production and relations of production increases as the forces of production advance. Science and technology advances have increased the skills of the workers therefore increasing productivity. Advances in science and technology have led to more effective tools and machinery. This has contributed to increased productivity. This increase value in the role of skills, tools and machinery should serve to empower the workers. However, capitalists seek to maintain control over production by making the relations of production more complex. More complex systems of taxation, public stock companies, pension funds, mortgage and other consumer credit and shifting between public and private services all serve to make relations of production more robust and confusing. This serves to further capitalist control.

The relations of production, also addresses the distribution of the products, services and profits from the work done [19]. This is more straightforward when manufacturing and selling products. For example, in an automobile factory we have workers, levels of management and owners of the factory. The owners control distribution of products and the profits from the production process. In the public service sector, it is more complex. The public service sector itself is very diverse including social security services, transport services, educational services, health services, and postal services. Some of these services operate as independent for-profit enterprises while others are government controlled and/or not-for-profit services. Government controlled services are often funded through government taxes such as basic education and public libraries.

The relations of production in the service industry vary from service to service. For medical services the doctor or medical practice, owning the means of production, controls access to the medical services, sets prices and controls the profits. Government services that directly address the needs of people such as social security, passport processing and postal delivery require funding from the government instead of creating profits. The setting of wages and benefits for workers in these services is based on the organized power of the workers, the relative importance placed on these services by a broader public, as well as the pressure put on the state by the dominant class. The funding and functioning of these services are determined by regulations and policies set by government. In most of the world, the dominant class consist of wealthy capitalists. The capitalist ownership of large tracts of land, factories, farms and mines gives them the power to dominate in the government and public sector arena. While capitalists directly control the means of production in their factories, farms and mines, they indirectly control the means of production in the public services sector.

In general, capitalists support the market approach. This calls for minimum government involvement in providing services. Minimal government involvement means less funding for service workers, and their training, equipment and facilities. These are the forces of production. This reduced support reduces worker job security, as well as worker productivity. This in turn can make private sector alternatives more profitable choices.

Policies are implemented to maintain and advance production. Policies that reinforce the relations of production strengthen the role of the dominant class. The historical role of public policy is to maintain stability and increase productivity, development and wealth. Policies can either reinforce or shift relations of production. Policies also can be used to spur innovation to advance the techniques and technology aspect of the forces of production.

5. Results and Discussion

An equitable process for national development requires: 1) a shift in relations of production where the majority of people own and control the nation's resources; and 2) development of the forces of production where the technology is more socially relevant and the skills, techniques and technology provide more power to workers. The later change empowers a broader population, and positions that population to pressure for changes in the relations of production.

Policy analysts and informatics specialists should focus on systems, problems and solutions that facilitate both this development of the forces of production and shift in relations of production. This requires recognizing the unequal development within a nation and between nations. Informatics must be used to study the problems that persist due to this unequal development. Informatics must also provide scenarios and policy alternatives which provide solutions that empower a broader population.

Policy informatics is a relatively new field of study. One view is that "policy informatics is an analytical approach that comprises concepts, methods and processes for understanding complex public policy and management problems".[1] This is broader and distinctly difference from informatics policy. The study of informatics policy is limited to concerns and policy that impact the use and development of informatics practices and resources. Policy informatics uses computational methods to organize, process, and visualize vast amounts of data, information and knowledge regarding a wide range of policies. These methods are organized to make complex systems and problems more understandable and manageable.

> "Stakeholder engagement is a critical part of policy informatics practice. Policy choices reflect the interplay of social, economic, cultural, and political considerations and policy making processes can take many forms that vary in accessibility to outsiders and that give different advantages to the input of experts and other interests"[1]

When dealing with public policy the stakeholders are the broad population impacted by the policies. It is important that special interest experts and lobbyists are not allowed to establish policies that continue or aggravate uneven development.

Three cross cutting themes are recommended to promote a policy informatics agenda that is most equitable. These themes are: 1) computational thinking, 2) socially relevant problems and examples and 3) ethical, humanist solutions grounded in historical materialism.

The focus on computational thinking is applied to problem solving across the range of courses in the curriculum.

> "Computational thinking is thinking to solve problems, automate systems, or transform data by constructing models and representations, concrete or abstract, to represent or to model the inner-working mechanism of what is being modelled or represented as an information process to be executed with appropriate computing agents." [20]

Computational thinking involves a number of thinking concepts. These concepts are captured in Table 2.

Table 2 Concepts involved in Computational Thinking (adapted from [20])

Concept	Explanation
Logical	To capture what is essential to the models or representations
Algorithmic	To step-wise define or refine operational processes
Scientific	To gain understanding of models' capabilities, learn how to use them with maximum efficiency, and explore the effects of the computation in the original problem domain.
Mathematical	To be able to show the correctness of algorithms, specify precisely the functionality of a software system, measure the quality of what we do in a process of computation, and deal effectively with the complexity of the models and representations by exploring more effective and efficient alternatives;
Analytical	To model with purpose, assumptions and viewpoints, evaluate and adjust the models and representations by prototyping, and study their implications and consequences;
Engineering-oriented	To design the models and representations against known constraints and practical concerns. To plan, execute, manage, and evaluate the process of computation in order to improve our capability and maturity level;
Creative	To model the unthinkable
Systemic	To take a systems view where the system consist of elements or part with attributes. The elements are connected by relationships. Frames, networks and object-oriented design are all systemic.

The selection of problems and examples across the range of courses should be based on social and cultural relevance. The problems and examples should be relevant to Africa and relate to empowering the majority and disadvantaged populations. The conception of a discipline is largely shaped by the examples provided and the problems addressed in studying a given discipline. The training of innovative people-centred policy informatics graduates depends on how successful the curriculum is in developing these socially relevant problems and examples.

Throughout the policy informatics program, when addressing problems, an ethical philosophical grounding of humanism should be reinforced. Humanism views the development of woman and man as the ultimate end. With a humanist grounding, it is natural to employ historical materialism to reshape the socio-political policy milieu. The forces in tension are identified when considering each situation. Problems are examined in terms of the forces of production and relations of production. Plausible policy solutions advance the welfare of the majority and disadvantaged populations while considering the ecological balance of the planet.

The recommended policy informatics curriculum is summarized in Table 3. The table divides the curriculum modules into four categories: core, informatics fundamentals, policy studies and electives by tracks. Modules may correspond to an individual or multiple courses or modules may be combined into a single course. The particular institution will decide on the module to course relationship based on institutional constraints and their particular program goals.

Table 3 – Modules for Policy Informatics Bachelor of Science Program

Core	Informatics	Policy Studies	Electives by Track
-Problem solving and programming - Data Structures -Algorithms -Thinking paradigm -Political economy of developing countries -Appropriate Technology	-Modelling and Simulation -System dynamics -Knowledge Management -Data Mining -Information systems strategy -Artificial Intelligence -Expert systems -Operations Research (OR) -Human Computer Interaction -Information Visualization	-Public policy theory and practice (domestic and international) -Development studies -International policies and organizations -Urban politics -Policy and security -Technology policy -Econometrics -E-government and e-governance	**1)Modelling & Simulation** -Agent based modelling -Statistical analysis of simulation outputs -Advanced topics such as Queuing theory, Markov models **2)Knowledge Systems** -Organizational Learning -Knowledge acquisition -Advanced topics such as: Case based reasoning, knowledge representation **3) Analytics** -Advanced OR: integer, non-linear and dynamic programming -Regression analysis and forecasting -Geographical Information systems

The core modules are all first year modules. Additional first year material covering mathematics, statistics, science and humanities should be included to match the institutional requirements. The informatics and policy studies modules should all be required. Electives from one of the three tracks should be taken during the final year to complement the final year project. It is recommended that students spend 6-18 months (starting their 3rd year) on attachment with an agency or institution engaged in policy studies. The institution can design the program to take four or five years. The length of the program should be determined by the number of institutional courses required, the length of the attachment period and the significance placed on the final year project. During the final year, all students will develop a major informatics project. The project should link to one of the three informatics tracks and if possible build on the student's attachment experience.

6. Conclusions

The teaching methodology should focus on a learner-centred approach and rely strongly on collective problem solving, real world examples and case studies. The resulting policy informatics program presented in Table 3 is intentionally general. The particular course construction should be based on the national and institutional constraints and policies of the particular situation.

Table 4 provides an example curriculum based on institutional guidelines at Howard University. Howard University does not have a full year attachment program. Instead, students can spend three months working in industry or with an agency over the summer. This curriculum is designed expecting students to spend the summer after their 2nd and 3rd years working for an organization affiliated with this policy informatics program. The final year is devoted to technical electives and the final year project. There are a number of general education courses required of all students such as Speech, English, Mathematics and Physics. All normal programs at Howard University are required to allow students to complete in four years with 120 credits. Each credit is equivalent to one hour of lecture per week for a 16-week semester. Most courses are 3 credit hours (CH) requiring 48 contact hours during the semester.

While the particulars of the program are determined by national and institutional constraints, there should be common guidelines for evaluating the success of a program. The courses should be evaluated on how well they address the crosscutting themes of: computational thinking; socially relevant problems/examples; and 3) ethical humanist solutions grounded in historical materialism. The practical experience with the organizational partner should be based on relevancy determined jointly by the academic advisor and the organizational partner. The final year projects should be the third measure of success for the program. Projects should be evaluated on how well they serve as a capstone utilizing techniques and skills learned in the taught courses and practical work experience.

Table 4: Policy Informatics Curriculum based on Howard University Requirements
(courses in italic are required university general education courses, CH indicates credit hours)

1st Year 1st Semester	CH	1st Year 2nd Semester	CH	2nd Year 1st Semester	CH	2nd Year 2nd Semester	CH
-*English I*	3	-*English II*	3	-*Linear Algebra*	3	-*Differential Equations*	3
-Problem solving and programming: Python	3	-*Calculus II*	4	-*Physics I*	4	-*Physics II*	4
-Thinking Paradigms	3	-*Discrete Maths*	3	-*Probability and Statistics*	3	-*Biology*	4
-*Calculus I*	4	-Data Structures and Algorithms	3	-Intro. Public Policy: theory and practice	3	-Artificial Intelligence and Expert Systems	4
-Political Economy	3	-Appropriate Technology	3	-Operations Research	3		
3rd Year 1st Semester	CH	3rd Year 2nd Semester	CH	4th Year 1st Semester	CH	4th Year 2nd Semester	CH
-Modelling and simulation	3	-System Dynamics	3	-Policy and Security	3	-Technical elective III	3
-Development Studies	3	-Knowledge Management and Data mining	3	-Technical elective I	3	-Final year project part II	9
-Urban Politics	3	-Technology policy and e-governance	3	-Technical elective II	3		
-Econometrics	3	-International policy	3	-Final year project part I	6		
-*Speech*	3	-HCI and Information visualization	3				

7. Future Work and Discussion

This policy informatics curriculum will be presented to the National University of Science and Technology (NUST) for review, evaluation and revision. The Science Faculty at NUST has decided to develop an Informatics Bachelor of Science program. The Computer Science Department was tasked with designing and developing the program. The department decided a policy informatics curriculum was a good niche program that addressed the needs of the country. The principle author of this paper was tasked with researching public policy and informatics programs and proposing a policy informatics curriculum. Many of the modules in the suggested program have been taught by the authors. Most of the modules in this curriculum have been taught at NUST or Howard University.

Further investigation and development of detailed course content and potential final year projects is planned for this academic year. Research will be conducted to identify relevant examples and problems to address across the curriculum. The identification of agencies and institutions that will partner with NUST to host students on attachment is a key part of future efforts. There will be efforts to identify government, Non-governmental organizations (NGOs) and private enterprises to host students and assist with final year projects.

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International Cooperation in ICT and/or Engineering Education

Keeping the Virtual Real

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Abstract

Students are increasingly being exposed to a virtual world in their personal life and throughout their engineering degree programme, both in the classroom and using simulation software and/or remote laboratories in the experimental programme. The consequences of these changes are that the students are getting less and less "hands-on" experiences that were inherently part in their personal life and the traditional laboratory experiments. Engineers, though, work in the real world, producing artefacts and creating software, not just using them. Providing the students with a facility, where they can conduct experiments and projects, will help the students relate the virtual world of their courses, including laboratories, to the real world of engineering. The initial idea and the experience of developing, managing and running of an informal engineering skills development laboratory and its contribution to the training of our future engineers is presented in this paper.

Keywords: *Engineering Education, Engineering Laboratories, Student Engagement.*

1. Introduction

Increasingly, technology based systems are being introduced as teaching aids in most engineering degree programmes worldwide. In the classroom the systems include electronic feedback systems, such as clickers [1], multimedia and animated presentations [2], on-line videos of lectures and interactive on-line tutorials [3]. On the experimental and laboratory sections of the engineering curricula, hands-on laboratories have been replaced by simulation software [4] and remote laboratories [5]. Our first-year students are also "expert" at using technology, spending hours running "Apps" on the various communication devices and computers, but are far removed from the reality of the technology. In a first year mathematics class, where the mathematics for modelling a screw-jack was discussed, only 30 out of a class of about 180 students had ever seen a screw-jack and even less had actually used one [6], making the discussion purely theoretical with no reference to real life.

Although the use of technology in teaching has both financial and time benefits for the institution, in reality the students we are teaching will become engineers, designing, analysing and manufacturing real things such as motors, electronic equipment and writing "Apps", not just using them. Over a number of years the author and other academics in the school had observed that the "start-up" time for students doing their final year laboratory project has been getting longer as more virtual reality was introduced into their courses and especially in their personal lives. As a result of these observations the curriculum was changed to put an increased emphasis on the build part of the "design and build" projects in the second year courses and their third year design course.

In an attempt to provide space for the students to work outside their allocated laboratory times, improve the students' "hands on" experience and develop an interest in engineering as a hobby, the author developed the concept of a "Playpen" [7], or Engineering Skills Development Laboratory (ESDL. The concept is to provide the students with a physical space, equipped with basic power supplies, measuring equipment and hand tools where they can undertake their projects and develop into engineering students with electrical engineering as a hobby.

The ESDL has been running for 18 months, with low funding, and is managed on a day-to-day basis by part time students. At present the ESDL can accommodate up to 80 students at 40 workstations although "time sharing" of equipment is sometimes required during the peak periods. Although students, at the last minute, often use the ESDL to complete their assigned projects there have been many successful hobby projects. In this paper the initial idea, the experience of developing, managing and running of the ESDL and the results from monitoring the usage and projects undertaken are presented.

2. The "Playpen Concept"

A paper by Froyd et al [8] describes the five major changes that have happened over the last 100 years in Engineering Education. The third major shift they describe is the "Renewed Emphasis on Design". This change has increased the emphasis of creating artefacts as well as the conceptual and mathematical design for a product. A number of universities have made large monetary investments creating laboratory and manufacturing facilities to develop engineering design skills in their undergraduate students. Two examples of this are the Yumekobo ("Factory for Dreams and Ideas") at the Kanazawa Institute of Technology [9] and the Integrated Learning Centre (ILC) at Queen's University [10]. These large facilities are enormous investments both in infrastructure and human resources.

Analysis of the abilities of our first year intake [7] shows that, irrespective of the social, economic or demographic backgrounds, most of our students lack imagination in the engineering context. This is especially a problem when teaching electrical engineering, as the basic concept of current is "imaginary": a whole discipline base on an imaginary concept! Brookfield [11] states that imagination is the most important requirement for critical thinking, which is a basic requirement for a successful Engineering design.

The concept of the "playpen" is based on a child's playpen where you throw in lots of toys, books and other things that may interest them, and then let the child decide what to throw back at you and what to play with. The idea is to have an area with basic equipment (oscilloscopes, power supplies, multi-meters, hand tools and basic components) where students can interact, form formal, or informal, "hobby clubs" and undertake projects as individuals or groups to explore and develop their engineering imaginations. The "Playpen" is officially named the Engineering Skills Development Laboratory, as "Playpen" was not considered, by the University's administration, as a suitable name for a University facility. The EDSL is not intended as a formal extension of the teaching programme and students are encouraged to use it without supervision from the academic staff. It is a place for the students to have fun and explore on their own using the type of instruments also used in their formal laboratories.

3. Methodology

There was no particular scientific study involved in development of the ESDL as it is based on more of an engineering research method as described by Johnson [12]. This approach can be described as: *An artefact was needed to solve a perceived problem, and therefore was created*. A successful outcome of the ESDL would be students using it for their own personal projects and experiments as well as those needed for their course. By continuously monitoring the use, number of projects and type of projects produced by students will give an indication of how successful the ESDL is.

4. Funding Requirements

Funding the ESDL has been a problem as it is a new concept being introduced at the time the University was building new and upgrading existing lecture and laboratory facilities to accommodate a large increase in our student intake. One benefit was, with the upgrade of the engineering building, space for the ESDL was planned for and made available. As part of the upgrade the school's Basic and Control laboratories were doubled in size and workbenches and new equipment purchased for them. This was a mixed blessing for the ESDL as traditional industrial sponsors to the School had made large donations to upgrade the laboratories and were not really open to further donations for the ESDL, especially as the ESDL would need on-going sponsorship for maintenance and human resources. The upside was that there were old workbenches and old equipment available from the laboratory upgrades and the decision was made to open the ESDL in 2012, with whatever we could scrounge from other laboratories and the human resources budget.

5. The ESDL

5.1 Infrastructure

The ESDL has 260 m^2 of available space consisting of an open area and the manager's office. The open area is divided into three distinct areas namely: Library/study area (Figure 1), and the electrical workstation area (Figure 2) and an area for mechanical construction with basic hand-tools.

Presently there are 24 workstations consisting of an analogue oscilloscope, a signal generator and a power supply and a total of 7 digital multi-meters to be shared and used as needed.
The workshop area is equipped with various hand tools such as screwdrivers, pliers, Alan keys, saws, hammers, hand drills and drill bits etc. In addition to the workstations there is a soldering station, with two soldering irons and two computers used for software development, programming microprocessors and printed circuit board design. The manager's office also houses the school's printed circuit board manufacturing equipment, which has enabled some students to design and produce their own boards.

Figure 1. Library/study area

When the first year class was polled in 2007 [7] a model car-racing track came out at the top of their list of "desired" requirements for a "playpen". Figure 3 shows the track and cars that was purchased and the assembled and constructed by the students. The Transnet Centre of Systems Engineering is supplying the funds and procuring a state of the art model train system for the EDSL. Both the model cars and the train set will also be available to undergraduate students for their honours projects as "test beds" for both electronic and control projects. The Transnet Centre of Systems Engineering is also intending to use the train system for post-graduate projects.

Figure 2. Electrical workstations

5.2 Human Resources

The human resource requirements have been one of the most challenging aspects of running the ESDL. Ideally the ESDL manager should be employed in a full-time position and have the necessary skills to manage the students while providing them with a safe environment, in terms of the occupational health and safety regulations, and technical support. Without the required funding the ESDL has been managed and run by students with no or very light academic loads.

Figure 3. Model cars

Students who, during the term of employment, do not have any courses to undertake have filled the manager's post. In 2012 the post was filled by a student that had been excluded from the university and with her enthusiastic approach to the concept made both a success of the ESDL and was re-admitted to the degree programme in 2013. In 2013 the EDSL has had two managers, a student with no courses in the first semester and another student with no courses in the second semester. The rule that the manager must have no other commitments while employed, is strictly enforced to prevent the duties in the ESDL impacting on their academic careers. The manager is supported by two students, with low academic commitments, working a maximum of six hours a week.

5.3 Utilisation and Projects

The students have used the EDSL for three main purposes [13]:

1. Supplemental work for their laboratories and projects:
   The ESDL provides space, tools and instruments for students working on their coursework projects allowing them more time, while at the university, to experiment and build outside the assigned formal laboratory times. Many students, in all years of study, use the ESDL for preparation for their laboratory tasks. This is normally in the lunch break before the afternoon laboratories begin. Of course the ESDL is completely full just before the projects' completion dates!

2. A number of individual and group projects were completed in 2012. These include:
   - A number of robots (see Figure 4),
   - a micro-FM transmitter,
   - magic oscilloscope,
   - constant current source with IV curve representation
   - GPS controlled car,
   - Wimhurst machine (see Figure 5) and
   - a CNC machine.

   The students without any input or supervision from any staff member undertook these projects. Their fun, their exploration and their satisfaction, while developing the intrinsic motivation to study in the field of Electrical Engineering.

3. Recreation:
   The model car-racing track has attracted students to the ESDL when there is a lull in their workload and the library section is considered a social meeting place as well as a venue to discuss group projects and for exam preparation.

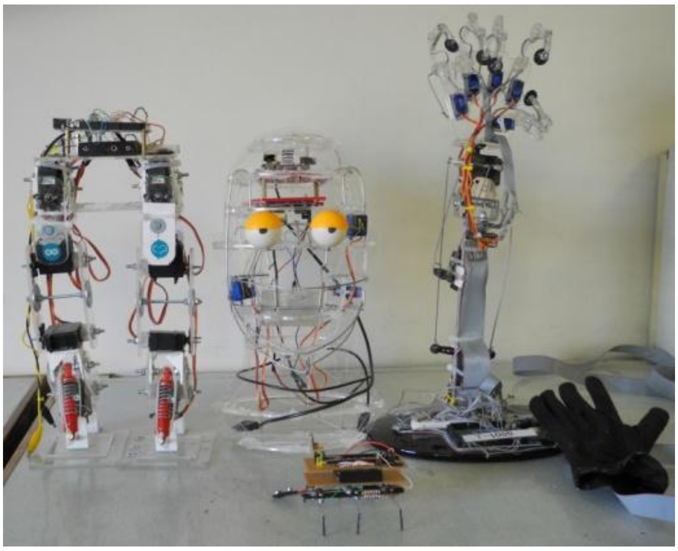

Figure 4. Various Robots

Figure 5: Wimhurst machine and 1st year catapult project.

6. Usage of the ESDH

The ESDL is open 8:00 to 17:00 every weekday and is closed during the summer vacation, although it is often used by students doing vacation work projects for staff within the school. Analysis of the usage by the students indicates that the average number of students using the ESDL shows a range from 10 to 90 per day. The low figure is during vacation times and the high figure just before project hand-in dates. At peak times during the high use period more than 200 students are trying use the facilities and spill out into the atrium area outside the laboratory. The peak time period for the laboratory is between 12:30 and 14:30 every day, the “extended” lunch break that students have available in their timetable.

The University of the Witwatersrand is essentially not a residential university with most of our students living off campus and many travelling up to four hours a day to attend lectures and laboratories. For these students the ESDL provides a convenient location to meet their project partners and work together on the projects. There have been numerous requests from students to have access to the ESDL on a 24/7 basis or at least until 19:00 during the week and on Saturdays. With the present staffing model it is not possible to open the ESDL outside of the “normal” operating times of the University as the occupation, health and safety requirements for the EDSL are met as the ESDL staff are overseen by the academic staff and workshop personnel during 8:00 to 17:00.

7. Conclusion

Funding of the ESDL manger is the most important next step in the development of the facility as this would enable extending the hours it is open making it more “user friendly” for the students. This would allow for the social experience to improve, as students from different years would interact, as they would not be confined to their respective timetables.

Monitoring of the utilisation, the artefacts created and the projects undertaken, over the eighteen months that the ESDL has been in operation, indicate that there was a need for the laboratory within the academic programme of the School. The fact that there were many personal projects, not required by the school, indicates that the objective to develop an interest in engineering as a hobby was met with a number of our students. Monitoring will continue and adjustments will be made where these are deemed necessary. The immediate priority would be the extending of the time that the laboratory will be open.

The ESDL provides electrical engineering students with a place where they can learn that engineering is about building artefacts and not just playing “computer” games, such as simulation software and remote laboratories. This will help them relate the real world, where engineers actually work, with the virtual world often found in a university environment, develop their engineering imagination and most importantly have fun.

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Presenter: This paper is presented by George Gibbon

A CQI System to Enhance Effectiveness of an EEA Programme

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Abstract

Initiated by the Accreditation Board for Engineering and Technology, (Abet) was an effort to cope with the need to effectively regularize and measure natural science and engineering higher education in the US, the idea was later introduced in Korea. The underlying philosophy of Abet is outcome-based education and the assessment of its learning outcome. To achieve continual quality improvement (CQI), was introduced by the Accreditation Board for Engineering Education of Korea (Abeek), active participation of an entire faculty was recognised as being vital. However, some professors experienced difficulty in completing a self-assessment report for accreditation, CQI being not appropriately reflected in the educational set-up. For this study need assessment and system implementation were studied through a method of effectively reflecting a CQI programme to cover the entire information system and incorporating operators' needs and opinions.

Keywords: *Abeek; requirement analysis, CQI.*

1. Introduction

The Abet was introduced into US tertiary education to try to negate an on-going problem with natural science and engineering theory recognition and evaluation; later it was extended to Korea. Then, recognising the importance of creativity in science, technology, engineering, art and maths (Steam), Abeek was established in 1999. It introduced an accreditation system for those involved with engineering education, incorporating industry, universities and research institutes. The system sought to assist develop engineering programmes for undergraduate students which enhanced quality of engineering education. Today, most engineering colleges implement engineering education accreditation (EEA) and expect students to benefit from employment opportunities, through EAA acquiring additional credits from industry. However, few engineering graduates receive accreditation; a majority cite little benefit from EEA. Moreover, students struggle to meet graduation criteria and fulfilling EAA requirements; professors are gradually losing interest in the programme [1]. The primary cause of problems is found in programme quality control (QC). Since EEA's core is outcome-based education, assessment and analysis is required to determine if the learning outcome set for each programme has been achieved and if results are reflected accurately in curriculum operation [2].

In spite of each college setting up its innovation centre, the assessment system remains misunderstood, leaving many programmes seeking improvement; proof being calls for improvement at forums and workshops [3]. To achieve CQI, emphasised by Abeek, continued assessment is required to evaluating all programmes. Furthermore, the effect of assessment criteria, such as teamwork and communication skills, on creativity and Steam also needs investigating, based on achievement requirements and consideration given to input and outcome. This was the scope given by the writers to the programme logic model [4]. This study offers EEA improvement measures via a need analysis for operators, enhancing total effectiveness and increasing the standard of self-assessment reports.

To this end, the study attempts to reflect operator need when reflecting CQI in a total information system, increasing the input ratio of CQI, a major part of accreditation and operating EEA instructing faculties to ensure effective progress.

2. Theoretical Background

As shown in Figure 1, the core of engineering education accreditation in Korea and the US lies in enhancing graduate competence and quality through CQI, driven by outcome-based and demand-driven education [5]. Demand-driven education indicates educational goals, but to achieve outcome-based education, curriculum must be organised and operated so goals and learning outcome are achieved and, in turn, assessed and analysed based on on-going measurement. Also, a system established to continuously improve quality by reflecting assessment results, followed by an analysis every three years is required.

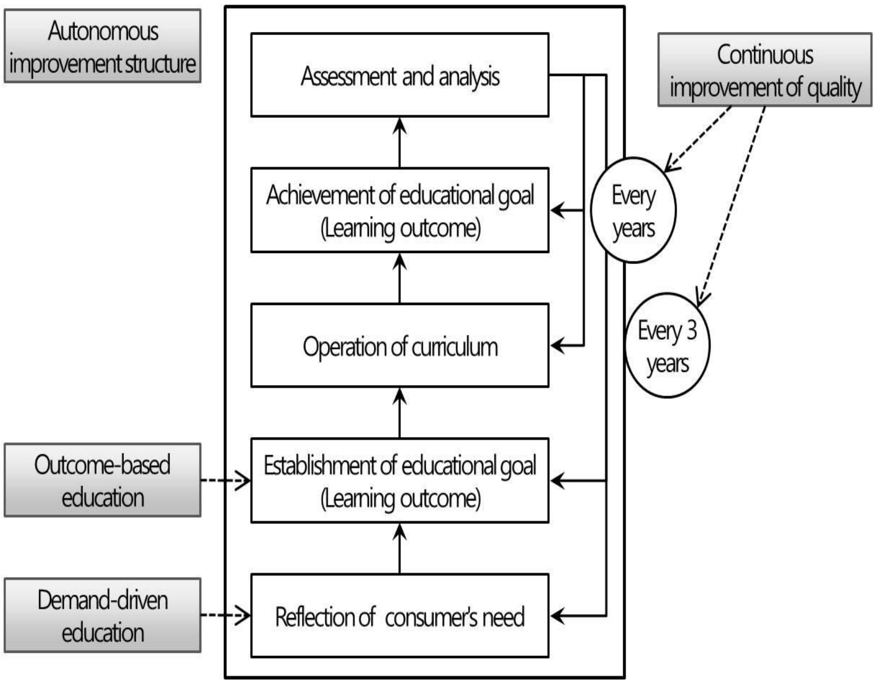

Figure 1: Continuous CQI

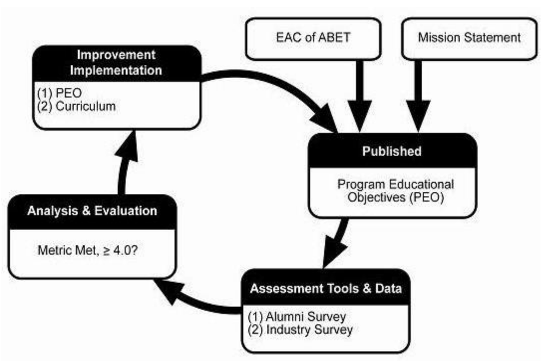

Figure 2: Assessment and modification procedure of the ABET programme in the US

EEA is not a certification granted individuals, but a specialised accreditation assuring engineering education programme quality. The Abet in the US was established in 1932; Abeek in 2001. In spite of the historical gap, criteria and assessment procedures for EEA are similar; both accepted international accreditation compliance through the Washington Accord [6].

2.1. College engineering accreditation programmes

The Abeek presented the criteria and guidelines for its programme to foster talent by implementation, accreditation and consultation. It was established in August, 1999 and became operational in 2001. By 2009, 509 programmes at 63 institutions were accredited; another 411 programmes at 65 universities are in line.

EEA is a system assuring graduates of accredited programmes are well-equipped for their majors and show competence to enter industry. EEA seeks to promote the development of engineering education, producing competent engineers and technicians by presenting their criteria and guidelines implemented via accreditation and consultation [7].

2.2. Re-engineering

Software re-engineering refers to a process of modifying, enhancing and maintaining the function and design of existing system through use of automated tools [8].

Such software product line engineering is a paradigm assisting organisations develop software from re-usable assets, rather than from scratch - improving quality and productivity. For this study, CQI was implemented to allow re-use of school information systems through re-engineering. To demonstrate feasibility a component model, identification method, separation method, and a supportive tool were created.

3. Implemented Screen of CQI Report

An EEA programme should complete a detailed self-assessment report based on accurate data, proving it met accreditation criteria requirements. It should determine a CQI programme through: goal-setting by major accreditation criteria, establishment and operation of a system for goal achievement, establishment of an assessment system and data collection to measure outcomes (or status), analyse data to derive improvement measures and in particular include data collection and analysis to measure goals.

A need analysis was performed for effective completion of CQI with programme director professors (PD) of each programme through a self-assessment report. Results sought were:

- Curriculum CQI report be entered before entering grades into the total information system and confirmation of curriculum CQI of EEA entered *before* entering syllabus;
- Active faculty participation in completing CQI reports; not an entire semester's grade or next semester's syllabus without entering a curriculum CQI report and,
- Integrity of a CQI report should be ensured by allowing the curriculum to be later modified.

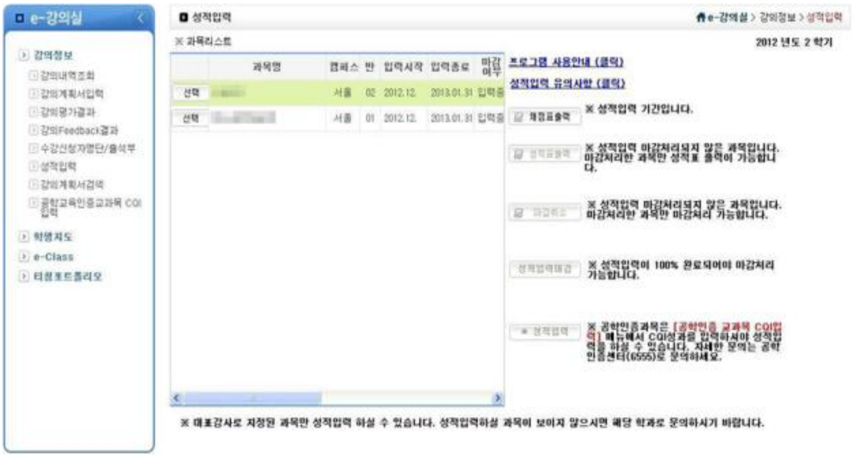

Figure 3: Input screen of CQI report and grade entry

Figure 3 shows an implemented screen enabling CQI to process grades and used as a management system for the engineering accreditation programme for convenient use by students and educators.

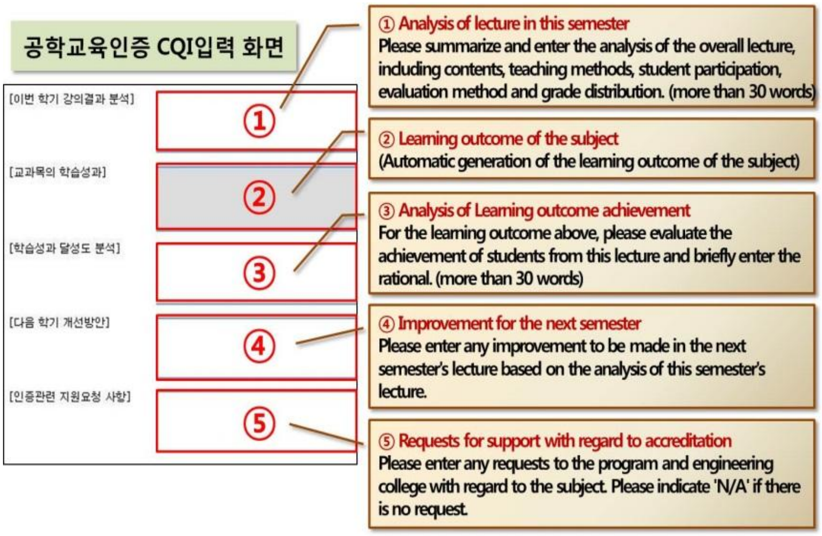

Figure 4: Input screen of CQI report

Figure 4 demonstrates an example of CQI increasing convenient use in regard to modification being required. After grades have been entering, the template wordings may be modified through "'Input of CQI report for engineering education accreditation."

In the EEA, CQI refers to "continuous quality improvement;" in curriculum domain, it indicates "improvement of lecture quality." A curriculum CQI report is a statement for quality improvement of lecture, completing the CQI report assists in class integrity facilitates a self-assessment report.

Figure 5 shows a CQI report requiring completion before a syllabus is entered.

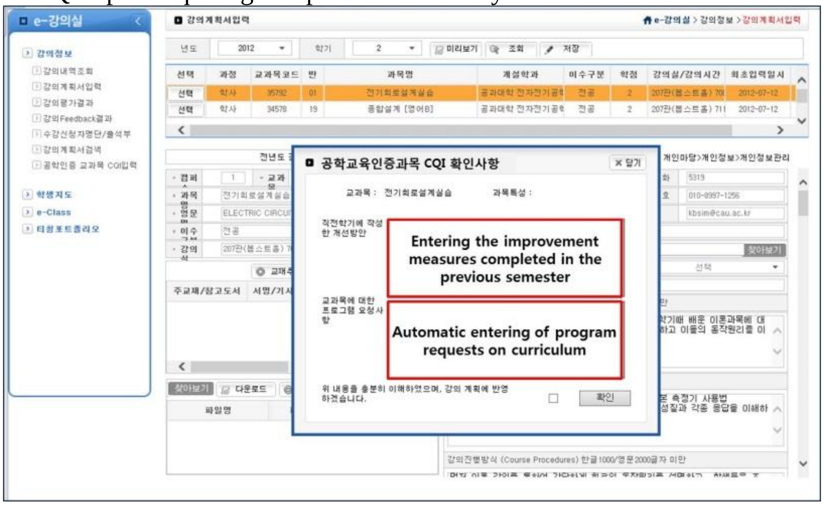

Figure 5: Input screen of CQI report before a syllabus is entered

4. Conclusions and Discussion

This study sought to enhance graduates' competence and quality through CQI, based on outcome-based and demand-driven education - the cores of engineering education accreditation in Korea and the US, to bolster effectiveness of an accreditation programme for tertiary education engineering courses. Demand-driven education indicates an educational goal and the learning outcome of a programme and its parameters to meet the demands and needs of students and educators. To achieve outcome-based education a curriculum requires its educational goal and curricula outcomes be proven - assessed and analysed based on objective, reasonable and periodic measurement. A system should also be in place to regularly monitor and reflect assessment and analysis results to improve educational activities. Generally, curriculum improvement is required annually based on collected data; educational goal and learning, every three years. The contents of a CQI report, which should be implemented at both ends of a semester to effect CQI, are determined on need analysis; school system operator demand is also covered.

CQI report implementation was based on the Waterfall Model, methodology used in software engineering. For the CQI report programme, a basic system was adopted using a re-engineering technique from the existing system; several limited conditions were imposed, for example, a need analysis, for PD professors to complete a self-assessment reports. Results indicated:

- The curriculum CQI report should be entered into the total information system before grades and the confirmation of EEA curriculum CQI entered before syllabus;
- active faculty participation in completion of CQI reports be encouraged by a faculty entering semester grades and next semester syllabuses without entering a CQI curriculum report and,
- the integrity of a CQI report be ensured through subsequent entry and modification of a curriculum subject.

CQI report and grade entry software enables entry in progression; grades cannot be processed without entering CQI. The existing function, used as an EEA management tool, was implemented and it also became possible to develop an entire programme rapidly, saving development costs through system re-engineering. User convenience was enhanced through easy-to-use CQI input software. A comparison of pre and post CQI input use showed that although CQI was annually entered over two regular and two seasonal semesters - from 2006 to 2012at a selected university - the initial average rate of teaching professors' voluntary CQI input reached only 50%. Through continued promotion, however, average CQI input reached 70% by semester end; after input from professors further improvement saw the figure rise to 96%. Moreover, ease and satisfaction of use was made streamlined through template availability.

In this study, the analysis of requests for the development of a CQI system to increase the effectiveness of EEA is reflected indicating cost saving through re-engineering and re-use; CQI reports input proved to easy to operate throughout the programmes. However, follow-up is required to reflect CQI report contents regarding EEA curriculum, by establishing an effective management system for such reports.

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Presenter: This paper is presented by Juhyun Jeon

Enhancing the Education Quality by using the Quality System and Excellence System in Higher Education

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Abstract

This paper describes the way of implementing Quality Management System (QMS) according to ISO 9001 at the VSB – Technical University of Ostrava and the experiences with its use. The implementation of QMS was executed as a four year project. The experience from the pilot project part (implementation of QMS at selected faculty) was utilised during the following application project part (implementation of QMS at the remaining of the faculties). The effect of adopting the ISO 9000 approach on the quality of products of the university has not been fully evaluated till this time, but significant improvement of university culture has been recognised. The method used for evaluating of all effects of adopting ISO 9000 at the university is a self-assessment according to the EFQM Model Excellence. Author's personal experience and special information systems developed during this process with the help of students will be also presented in this paper.

Keywords: *Quality, Excellence, Higher Education, EFQM.*

1. Introduction

During the past decade, Czech universities have passed an array of important changes connected both with the change of political orientation and the convergence to the principles and legislation of the EU. Many things have changed – goals, sources, requirements, and conditions. The present management systems of universities do not reflect these changes, they still utilise the traditional principles and are deficient of any element of modern management.

The management of universities is based on the principles of "common law" that don't correlate in most cases with the actual requirements of a dynamically developing society. Many problems and nearly standard situations are solved by an ad hoc way approach. In many cases there are not clearly defined responsibilities and authorities. The management systems are without the desired level of transparency and formalisation.

Currently, the universities are situated in a competitive environment. It is the principal reason why they have to be identified as organisations providing services that satisfy their customers. To lead and operate an organization successfully, it is necessary to manage it in a systematic and visible manner. Implementation of Quality Management System (QMS), as an inherent part of university management, is a way how to reach this aim. The new management of the VSB – Technical University of Ostrava (VSB – TUO) decided to implement QMS after their election and appointment in first half of 2003.

2. VSB – Technical University of Ostrava

More than 150 years history of the VSB - Technical University of Ostrava is closely connected with the development of mining and metal extraction, which was the oldest industry in the Austro-Hungarian Empire. That is why the Emperor Frantz Josef I. decreed (1849) that a mining vocational school be set up in Příbram for the northern countries, and another in Leoben for the southern countries of the Empire. In 1904, the Příbram Academy was given the status of University – Vysoká škola báňská (VSB). The President of the Czechoslovakia, E. Beneš, issued a decree No. 49 on 8th September 1945 by which the university was transferred from Příbram to Ostrava. This ended the history of Příbram and opened a new era in the history of the university in Ostrava, the centre of a widespread chemistry, heavy engineering and mining region.

Figure 1. VSB-TU Ostrava campus.

The 17th November 1989 was a historic event in the life of Czech universities and in the whole society. Significant changes have been made at the VSB – Technical University of Ostrava (VSB – TUO). The reorganisation of all courses and the new provision of modern branches of study transferred the VSB – TUO to a modern polytechnic university.
The VSB –-TUO currently consists of seven faculties:
- Faculty of Economics,
- Faculty of Civil Engineering
- Faculty of Mechanical Engineering
- Faculty of Electrical Engineering and Computer Science
- Faculty of Mining and Geology
- Faculty of Metallurgy and Material Engineering
- Faculty of Safety Engineering.

There are more than 19 000 students in bachelor degree, master degree and doctoral degree programmes in presence, distance and combined studies.

3. Implementation of Quality Management System at the VSB – Technical University of Ostrava

Currently there are two basic concepts of QMS:
- the concept of ISO 9000
- the concept of TQM.

The concept of ISO 9000 is a prescriptive approach based on International Standards ISO 9000 series. These standards define what is necessary to do (ISO 9001) and how to do the things (ISO 9004). The ISO 9001 certificate is the way to communicate that the organisation implemented QMS successfully.

The concept of TQM is a non-prescriptive approach, more or less a philosophy. TQM is applied according to different models that enable the evaluation the growth of QMS. EFQM Model Excellence is used in Europe.

The existence of explicit defined guidance, which has been successfully verified many times in the industry, led to the decision to implement QMS at the VSB TUO according to the ISO 9000 concept. There are no principal reasons why the benefits of implementation of QMS in industry would differ in the case of a university. The decision was supported by the existence of ISO 9001 registration. The ISO 9001 certificate is an outstanding supporting material. It is evidence that proclaims a university is being properly managed, the needs of their customers are identified and the environment to satisfy them is established. To utilise the good practices from industry the management of VSB – Technical University of Ostrava employed a quality manager that had had long-term experience with QMS implementation and maintenance at the first class manufacturing company that was awarded by the Czech Republic National Quality Award 2001.

The VSB-TUO is a huge institution with lot of various activities. The implementation of QMS in the whole organisation simultaneously could be risky. The experience from the implementation of QMS in industry is not fully transmitted into the university environment. There are at least two important differences:

- The cycle time of product realisation is significantly longer than in industry.
- The members of university staff and academic freedom.

It was the reason why we split the implementation of QMS into several stages. As each faculty is a relative autonomous part of the university, the first stage (2004) was implementation of QMS at a selected faculty as a pilot project. This stage was successfully terminated and the Faculty of Electrical Engineering and Computer Science was the first faculty in the Czech Republic that received the ISO 9001 certificate. The second stage (2005-2006) was implementation of QMS at other faculties with utilisation of the experience from the first stage. The final on-going third stage (2007) is implementation of QMS at the administrative and executive parts of the whole university.

4. Benefits of Implementing QMS at the University

The time from the beginning to implementation of QMS at the VSB – TUO is rather short in comparison with the cycle time of processes at the university (3 years for bachelor degree study programs plus 2 years for a master degree and plus another 3 years for doctoral degree). It is too early to evaluate the effect of adopting the ISO 9000 approach on the quality of university products. However, we recognise the improvement of university culture in the following areas:

- **Increased level of managing processes at the university**
  It is the main asset. In the past, most standard situations were solved ad-hoc. QMS defines accurate rules.
- **Better set-up of activities inside the university, accurate definition of authority and responsibility**
  The process approach enables definition of activities and their relation inside the university with correspondence to authority and responsibility in a simple way.
- **Forcing the university to identify and satisfy the actual needs and expectations of their customers**
  In some situations in the past, the university offered what their staff recognised as important. Actual needs and expectations of their customers could be different. QMS forces the university to identify and satisfy the actual needs of their customers.
- **Saving operating expenses**
  A proper set-up of activities inside the university together with an accurate definition of authority and responsibility leads to elimination of wasted efforts and it brings savings in operating expenses
- **Improvement of educational processes**
  Identification of the actual needs and expectations of university customers, evaluation of

customer satisfaction, better set-up of activities inside the university leads to an improvement of educational process.

- **Improvement of competitive ability of university**
  ISO 9000 registration is a competitive advantage. It is evidence that the university is properly managed, the needs of their customers are identified and the environment to satisfy them is established.
- **Increased proactive behaviour of employees**
  The existence of defined procedures for problem solving (control of non-conforming products, corrective action, and preventive action) and tools for independent assessment of any designed process or activity (internal audit) leads the employees to proactive behaviour.

5. The Way to the TQM

The ISO 9001 approach is focused on customer needs. The university management system has to be oriented not only on their customers but also on their stakeholders (interested parties). ISO 9004 offers guidance for performance improvements by including the needs of stakeholders. But neither standard (ISO 9001 and 9004) offers an instrument for evaluating the maturity of management system. Therefore, we were looking for some efficient instruments for university management system assessment, which can describe the university life in a more complex way. Because we were focused on management improvement from the beginning and on the use of industrial standards, it is not surprising that we chose a very complex industrial quality assessment system based on the EFQM Excellence Model [1], see Figure 1. This model was also rearranged for education institutions [2, 3].

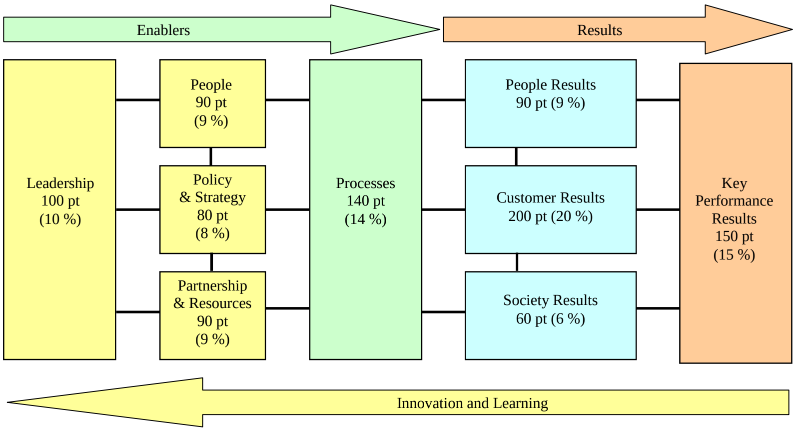

Figure 2. EFQM Excellence Model [1].

The progress of implementing TQM at the VSB TUO is nearly the same as in the case of implementation QMS according to ISO 9000. We started at a selected faculty as a pilot project and we will continue at other faculties by utilising the experience from the pilot stage.

Significant motivation for orienting on complex quality comprehension was also represented by the Program of the Czech Republic National Quality Award, which was opened for the first time in 2006 to non-profit organizations and extended with two categories – based on the CAF Model and based on the EFQM Model Excellence.

The Faculty of Mechanical Engineering was the pilot faculty where we started with implementation of the TQM philosophy. This faculty applied for the Program of the Czech Republic National Quality Award 2006 – a partial assessment of performance of an organisation based on EFQM Model Excellence.

The whole process of implementing the TQM approach was divided into the following steps:

1. Develop & retain commitment to faculty management.
2. Develop and deploy communication strategy.

3. Plan self-assessment.
4. Select and train people directly involved in the process of self-assessment.
5. Conduct self-assessment and write a self-assessment report.
6. External evaluation of a self-assessment report by assessors from the Czech Republic National Quality Award followed by a site visit.
7. Consider outcomes & prioritise.
8. Establish & implement an action plan.

Many analyses were done during the self-assessment process and more than fifty interesting faculty performance and efficiency indicators were found. Ten of them were selected as a base for the benchmarking project with other technical faculties from the Czech Republic and other European Union countries.

Parallel to finishing the self-assessment report, the most significant weaknesses and threats were selected and analysed so that the activities for their quick removal could start. Many uncertainties were eliminated by new analyses of questionnaires for graduates, new students and unsuccessful students. Many external analytical projects were joined and supported, like REFLEX focused on students who had graduated in the past three years, graduate employability, students assessment projects realised by the ACSA – Academic Centre of Students Activities at the same time as at all universities in the Czech Republic.

Another important area which was omitted in the past was collaboration with suppliers; especially it means collaboration with high schools. The project called “Partnership with High Schools” was started at the end of the year 2006 by specific offers for their study support like special excursions to the faculty labs, university teacher lectures focused on actual technical problems and innovations and other real collaboration support. Based on the evaluation of self-assessment report, followed by the site visit by assessors of Czech Republic National Quality Award, the Faculty of Mechanical Engineering was awarded “Recognised for Excellence”.

The experience with implementing QMS in the university environment has been recognised very interesting for all other technical universities, too.

Figure 3. Received award.

6. Faculty of Mechanical Engineering experience

The Faculty of Mechanical Engineering joined a project focused on applying the Quality Management System at the VSB – Technical University of Ostrava at the end of the year 2004 in concurrence with the pilot application of QMS at the Faculty of Electrical Engineering and Computer Science, which was the first faculty in the whole Czech Republic with a functioning QMS system. At the end of the successful certification of the QMS system at the Faculty of Mechanical Engineering in May 2005, it was clear that it would be a long way to fully implement all management instruments, especially those used by all faculty members at all management levels need a lot of work. The university management system is different from a typical company management system. The obtained results from the faculty QMS system have been very interesting for all other technical faculties. The main goals were presented at the International Conference on Engineering Education 2006 [4], 2007 [5], 2008 [6], 2009 [7], 2010 [8], 2011 [9] and as a part of the faculty Excellence System (best practices) [18]. It was very satisfying when representatives of two other technical faculties from the Czech Republic asked for cooperation meetings to transfer our results to their faculties. How important the quality assurance in higher education is, especially in the European Union, is described in many papers presented at previous ICEE conferences [2, 11, 16]. The use of quality management systems in higher education is more and more common, as is described in more and more papers, like [10, 13, 14, 15].

Our personal experience is that most important is to change people's minds. Very helpful was to establish a special working group “Quality group” joining the faculty members focused to the QMS system. The first problem for many of them was to define meaningfully the Faculty mission, vision and quality management needs. As the most important and also most helpful work, we indicated the identification and description of all processes. The UML (Uniform Modeling Language) Activity Diagrams had to be used as a suitable instrument for detailed process description. The first problem was to describe all processes according to all external rules and next to persuade all academics to work according to them. Although it was a surprise for us, many academics became accustomed to violate the hold rules as a result of “academic freedom”.

Next we were looking for other forms for developing the faculty management system, together with expanding standard QMS instruments, such as processes risk analysis based on FMEA (Failure Mode and Effects Analysis), SWOT (Strengths, Weaknesses, Opportunities, and Threats) analysis as a background for significant decisions, the consistent utilisation of preventive and corrective measures. The QMS model based on ISO 9000 norms is oriented on suppliers and customers, but the university is complicated and depends on its academic staff, which means we have to focus at least on our employees. Then we were looking for some more complex system, which can describe the university management system more complexly. Since we were oriented on industrial standards from the beginning, it is not surprising that we chose the system Total Quality Management based on EFQM (European Foundations for Quality Management) Excellence Model [1]. An important aspect of the model is the detailed self-assessment methodology, usable for a faculty or university [12], which is compulsory in the Czech Republic for all state universities, according to the University Act.

7. Related students projects

Student projects are a standard teaching method that has been used for a long time in subjects like Databases, Information Systems and many others. One project is usually dealt with by a team of three or four students. The main problem is that students do not have effective knowledge from this area and the main goal of this project is to learn more about solving a problem. It is almost impossible to connect these projects in solving some concrete problems for industrial partners. Another problem is the price of the newest hardware and software. In this case we have good experience in collaboration with some hardware and software producers, who give or borrow us their equipment for our laboratories. This way was also used during the implementation of TQM System for developing special information systems, typically to collect and present production data [8] or to support benchmarking [9] with other technical faculties. Both projects were solved during completion of Diploma Theses. Figure 4 presents an example of a developed information system for self-assessment support. The developed information systems helped to apply the TQM system very well, because they are all web oriented and are also available on all computers outside the university. Any university member is able (according to her/his authorisation) able to check data about the department, faculty or university.

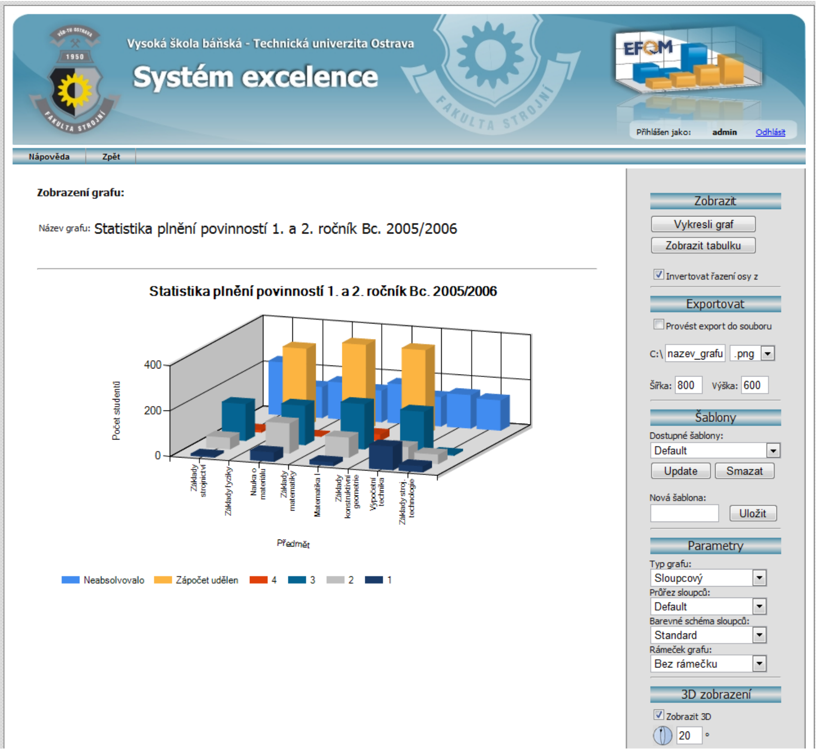

Figure 4. Web Based Enterprise Performance Appraisal Information System

5. Conclusion

The implemented QMS brings benefits both to customers of the university (students, employers, society) and the university itself. That is the reason why we started this process at the VSB – Technical University of Ostrava. The results of the implemented and certified Quality Management System at the VSB-TUO are very positive. Orientation on a complex quality system and the use of the EFQM Excellence Model has improved the university life, their processes and efficiency. Achieving official recognition for the Faculty of Mechanical Engineering from the Program of the Czech Republic National Quality Award has been promoted other faculties of the university. Thanks to this, we can recommend this way to all other technical faculties and universities.

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Assessment of Student Learning Outcomes in Engineering Education and Impact in Teaching

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Abstract

It is presented a conceptual model that aligns Learning Outcomes (LO) in Engineering Education (EE) with assessment strategies based on e-learning. The research problem was made taking into account three areas of research: Assessment, Engineering Education and e-Learning. The work managed to verify to what extent e-assessment methods may be used to measure intended Learning Outcomes of Engineering courses. The study was planned to facilitate the curriculum design, the teaching delivery planning, the recognition of e-learning courses and to improve definition of assessment tools. In general terms, the approach chosen was to develop a model that matches various common assessment methods to measure the achievement of the main Learning Outcomes (LO) in the field of engineering. This means that it should be possible for a teacher to define the intended LO of the engineering course and, considering this definition, to write proper and possible adequate assessment methods. The work done in the study proposes a conceptual model ALOE (Assessment of Learning Outcomes in Engineering). ALOE was used to describe the Learning Outcomes and the proper assessment and to achieve alignment between these two components of the educational process. The impact in teaching that resulted from the application of ALOE is evaluated based in some case studies. The impact is presented in terms of curriculum organization, assessment methods, teaching activities and learning evaluation results.

Keywords: *Learning Outcomes, Assessment, Engineering Education, E-learning, Teaching.*

1. Background and Field of Study

Since the last half of the 20th Century, the World has been experiencing rapid transformation in the field of Education, led by the changing Knowledge Society. As Peter Drucker [1] explained in 1996, in this new society access to work is only gained through formal education and not acquired through apprenticeship. Almost two decades have passed and this is already what is happening in some parts of the World. Education and schooling have become a major concern for the society and it is a priority in national and transnational policies. Higher Education (HE) and Continuing Education (CE) have been most affected by this transformation, adapting to the demand for new skills of the labor market and at the same time corresponding to the needs of an increasing number of students. The global economy created opportunity and need for the mobility of students and workers, demanding better recognition of qualifications and increasing competitiveness in this field. The labor market demands more workers qualified and updated. All this generates pressure towards a quality based approach in all Education providers, as Drucker predicted.

One visible effect of this transformation is the shift from a content based approach in Education to an approach centered on the student and what he/she has learned and achieved, the learning outcomes (LO). This approach is underpinning the development and implementation of most European Education policies at international and national levels [2], [3], [4]. In Europe, higher education (HE) institutions and continuing education (CE) institutions are redefining programs in terms of LO, harmonizing them with national, international and sector level frameworks of qualifications that are also based on Learning Outcomes. Several projects and initiatives are working towards the definition of LO, specific and transversal that can be used as a common reference. Learning Outcomes are also becoming fundamental for structuring the standards and guidelines of quality assessment of HE and CE institutions. In this context, the assessment of LO becomes a crucial process for the educational system. Measuring the real LO achieved by students, against the intended ones, using assessment strategies that are appropriate for the situation should be one main concern of HE and CE institutions.

Another major revolution in our society has been the introduction of Information and Communication Technologies (ICT). The use of ICT applied to education and to e-learning has been increasing and its use creates new opportunities for teaching, learning and assessment and has huge potential as an answer to some of the current challenges of education. The change to the digital media has impact on the availability, reusability, accessibility and cost of learning resources, complemented by the communication and networking potential of the Internet that takes education to a global level. E-learning is promoting change and innovation in different aspects of Education including pedagogy, technology, organization, accessibility, and flexibility among others [5]. It is a complex and multidisciplinary area and, given its impact, it is important that e-learning research be informed by evidence [6]. Current literature reviews in this area indicate that e-learning approaches to assessment lack pedagogical framework and most research describes implementation studies at course level [7].

The present research intends to contribute to establishing a pedagogical framework for the implementation of e-assessment in Engineering Education (EE). Finally, assessment is a crucial process of education and is seen by current trends as part of the learning process and not as a separate event. Assessment of student learning encourages involvement of student and provides feed-back to the student and the teacher [8]. It has an important role in validation and certification and is deeply related with quality issues.

This paper is placed in the intersection of these three fields: learning outcomes, assessment of student's learning and e-learning. It is focusing in HE and more specifically, in EE. The purpose of this study is to contribute to accrediting e-learning as an assessment delivery tool that can be applied independently of the learning pathways. It intends to contribute to the achievement of recognition and mobility of students and to the creation of a flexible Education System. In general terms, the approach chosen was to develop a model that matches specific e-assessment methods to measure the achievement of the main LO in the field of engineering. Again in general terms, this means that it could be possible for a teacher to define the LO of his online course and from this definition to have an indication of the assessment methods he might consider using. Formally, this problem is defined as "To what extent assessment methods may be used to measure intended the achievement of LO in engineering education?"

Given this problem, it was necessary to recognize that there were a wide variety of engineering schools, engineering programs and engineering courses. There are also different qualification frameworks that also use LO. So, the first challenge was how to select the LO that were going to be used for the purpose of the research. The same problem existed in relation to assessment. Assessment tasks are usually defined at course level, even though some examples can be found at a higher level. Again, there is a considerable variety of assessment tasks, some of them deeply embedded in the structure of the course or unit, i.e. at assessment tasks are highly contextualized. So, the first stage of the development of the conceptual model focused on the definition of the two main components: LO and assessment. The four questions addressed were:

Q1) Which LO in the field of Engineering are relevant and should be considered?
Q2) Which are the online assessment methods that should be considered?
Q3) What type of intended LO can be measured by assessment methods?
Q4) Is it possible to propose specific assessment strategies for each type of LO in EE?

2. ALOE Conceptual Model

The model for the alignment of intended LO in EE was developed from the concept of alignment defended by different authors [9], [10], [11]. In terms the alignment component, what is defended is that the LO of a course or unit should be used to define the teaching and learning activities, ensuring these will address the same LO. The same applies to the assessment tasks. To ensure the validity of assessment in relation to what is intended from the course, it is necessary that the outcomes measured by the assessment tasks are the same as the intended ones. The initial step to approach the problem was to identify and define the different components of the problem: the two variables, intended LO in EE and assessment methods; and the link between them that is the alignment question.

The main tool used for developing this conceptual model was the revised version of Bloom's Taxonomy [10]. This tool, designated in this paper as matrix rBloom (Table 1), is in fact an alignment matrix for LO, teaching and learning activities and assessment. However, for the current research project the adopted matrix assumed distinct functions: describe and classify the LO in the EE in a way that facilitates comparison between different levels and different sources; describe the assessment methods and e-assessment tasks; align the LO with the assessment methods.

Table 1 – Taxonomy Table by Anderson et al

Knowledge dimension	Cognitive dimension					
	1. Remember	2. Understand	3. Apply	4. Analyze	5. Evaluate	6. Create
A. Factual						
B. Conceptual						
C. Procedural						
D. Meta-cognitive						

The conceptual model suffered several iterations resulting from small implementations. The final version of the ALOE model was defined as a sequence of operations. The LO in EE at the qualification level are transduced to the EE program level using the rBloom approach. From the program level the LO at course level are defined using the same method. Finally the assessment tasks are aligned with the LO of the course level using the rBloom based method. It is clear in this sequence of operations that the revised version of Bloom's taxonomy is the main tool that will be used to achieve the stated goals of this work. Every LO from the ABET and EUR-ACE were described using the rBloom matrix. Each LO from the courses that were part of the case studies was described using the same tool. Also, an rBloom matrix was produced for each assessment method, mapping assessment to the cognitive processes and types of knowledge, based on the description of the methods found in literature research. A total of forty matrixes were produced for categories and general assessment methods. This set of matrixes is the actual alignment instrument of the conceptual model. They represent the standard against which the LO matrixes of the case studies were compared to produce aligned assessment strategies or to verify current alignment.

3. Learning Outcomes in Engineering Education

The first research question of this paper was how to select and describe LO in the field of EE that were going to be studied. On one hand, there was a need to use LO that could be generally accepted as a reference and that would capture the essence of EE. On the other hand, it was necessary to have LO that were specific and detailed enough to be workable, to be related with specific assessment methods. The qualification frameworks of Engineering have adopted LO as the qualification descriptors. It was decided to adopt a top/bottom approach, starting by using the LO defined by the Qualification Frameworks (QF) of the sector. This decision was important to ensure the validity of the application to the field of EE, as long as it was possible to maintain the link between LO defined at a lower level (program, course) to the QF. Two professional qualification frameworks (QF) were analyzed and described using rBloom. These are the most accepted internationally that are EUR-ACE and ABET and both are based on learning outcomes. This decision was also taken by the AHELO-TUNING project [11].
The analysis of the LO of both system that follows was important for the development of the ALOE model. This analysis may contribute for a better understanding of what a programme should address in terms of learning opportunities and assessment strategies.

3.1 ABET: Accreditation Board for Engineering and Technology

"ABET, Inc.", formerly named as Accreditation Board for Engineering and Technology until 2005, is an accreditation institution for engineering programs. In 1996 ABET started to change the accreditation process that was formerly based on institutional inputs to an outcomes-based system [12]. This system is composed of nine intended to assure the quality and improvement. The third criterion describes the eleven program outcomes that students should attain when they graduate at bachelor level and are known as "ABET a to k". The program outcomes are the following [12], [13]:

a) an ability to apply knowledge of mathematics, science, and engineering

b) an ability to design and conduct experiments, as well as to analyze and interpret data

c) an ability to design a system, component, or process to meet desired needs within realistic constraints such as economic, environmental, social, political, ethical, health and safety, manufacturability, and sustainability

d) an ability to function on multidisciplinary teams

e) an ability to identify, formulate, and solve engineering problems

f) an understanding of professional and ethical responsibility

g) an ability to communicate effectively

h) the broad education necessary to understand the impact of engineering solutions in a global, economic, environmental, and societal context

i) a recognition of the need for, and an ability to engage in lifelong learning

j) a knowledge of contemporary issues

k) an ability to use the techniques, skills, and modern engineering tools necessary for engineering practice.

Each programme accredited by ABET was described using the main tool of the conceptual model, the revised version of the taxonomy of Bloom. An example is found below, in Table 2.

Table 2. Example of analysis of ABET LO using rBloom

ABET a)	An ability to apply knowledge of mathematics, science and engineering
The analysis of this LO identifies a category of cognitive processes: APPLY. However it was considered that in order to apply the student will need to REMEMBER and UNDERSTAND. There are no clues indicating specific processes which are consistent with a LO at the level of QF. In terms of knowledge, there is no clear indication of types or subtypes so it was chosen to include the ones that are usually associated with the identified cognitive categories: FACTUAL and CONCEPTUAL. The template provided by Spurlin at al supports this classification of the LO. It identifies the necessary knowledge as general principles, theories, concepts and formulas. This clearly includes both factual and conceptual knowledge. In terms of cognitive processes, the term used is associated with applying. However, as Spurlin et al describe, to apply the student will need to define and describe. These may be classified in part as remember (recalling) and understand (interpreting, summarizing). The student will also need to explain (understand) and demonstrate, that can be classified as explaining and summarizing.	
Knowledge type	Factual Conceptual
Cognitive process	Remember: recalling Understand: interpreting, summarizing, explaining

3.2.EUR-ACE: Framework Standards for the Accreditation of Engineering Programmes

The EUR-ACE is a system that aims at developing a framework for the accreditation of engineering degree programs in the European Higher Education Area (EHEA) [14]. It intends to accommodate the diversity of existing programs, allowing the comparison of the educational qualifications and promoting the mobility of engineering graduates. The EUR-ACE system describes the requirements of graduates using program Learning Outcomes, both for first and second cycle. As with ABET and other accreditation frameworks, EUR-ACE describes the LO at a non-subject specific level and does not prescribe pedagogical methods to obtain the LO. The program outcomes of the EUR-ACE system are distributed among six categories:

1. Knowledge and Understanding;
2. Engineering Analysis;
3. Engineering Design;
4. Investigations;

5. Engineering Practice;
6. Transferable Skills.

These six categories apply to both first and second cycle programs (bachelor and master levels) but the descriptors are different for each level. The second cycle graduates should include LO described for both levels. The system provides an explanation of what is meant by each of the categories and provides a detailed list of LO. It is more detailed than the ABET criteria since it includes twenty two LO descriptors just for the 1st cycle of Engineering programs. Each category of LO was described using the Bloom revised taxonomy. An example of this analysis is represented in Table 3.

Table 3. Example of LO of EUR-ACE described using rBloom matrix

EUR-ACE 1	Knowledge and understanding
The description of this LO uses the terms knowledge and understanding that indicate two main categories of cognitive processes: remember and understand. The description does not give indication of the specific cognitive processes. Additionally there are indications about other processes. Coherent knowledge is related with analysis and specifically with organizing knowledge. Critical awareness is related with criticising.	
Knowledge type	Factual Conceptual
Cognitive process	Remember Understand Analyze: organizing Evaluate: criticising

As can be deducted from the analysis made, exemplified in the precedent table, it is concluded that the classification of the EUR-ACE competences for each EE program can be applied using the tool proposed based on the ALOE model. Consequently, in an analogous procedure of the ABET examples and tests, the LO of the EUR-ACE accredited programs are also capable of being used to align the LO of the programs and of the courses with proper assessment methods.

4. Assessment Methods Considered

The second research question of this paper was concerned with identifying and selecting the assessment methods to integrate the model. Early exploratory research in this field revealed some obstacles to reach the intended goal. Most of the published papers related with assessment descriptive case studies of the implementation of one particular type of assessment. Literature reviews on assessment [7], [15], [18] were not focused on specific methods or strategies but on logistical or pedagogical issues. It was not possible to find a systematization of e- assessment methods that would contribute to answering the second research question or to derive it from. These reflections on e-assessment led to more profound reflections on the nature of assessment and the research on this subject took some steps back some steps back. It was necessary to systematize some knowledge about assessment. The work of Brown, Bull and Pendlebury was of great help for producing a working list of general assessment methods, adapted from the work of Brown et al [19]. For the purpose of this research and specifically for the development of the model, six general categories of assessment methods were identified:

a) Multiple choice questions (MCQ)
b) Short answer questions (SAQ)
c) Essays
d) Practical case
e) Problems
f) Reflective practice

It was considered that these categories were too general to provide information for the alignment with the LO. It was necessary to add detail and specificity to the assessment. The categories were further analysed and detailed. A total of thirty seven assessment methods were identified and described in terms of knowledge and cognitive processes. Table 4 provides an example of the description of an assessment method using rBloom taxonomy.

Table 4 – Example of the description of an essay question

<table>
<tr><td>Essay 06</td><td>Discuss</td></tr>
<tr><td colspan="2">The student is asked to discuss a given fact or statement. This type of essay may involve describing the context, explaining the statement, comparing with other views, analyzing, evaluating the perspective.</td></tr>
<tr><td>Knowledge type</td><td>Factual
Conceptual</td></tr>
<tr><td>Cognitive process</td><td>Remember: recalling
Understand: interpreting, explaining, summarizing
Analyze: differentiating, organizing, attributing
Evaluate: criticising</td></tr>
</table>

In terms of the assessment methods and practices, the definition was also derived from literature. From the initial analysis, it was decided to drop the idea of assessment methods and replace it by assessment methods that could be implemented using learning technologies or assessment practices. This decision had consequences in terms of alignment, since it was now being approached from the perspective of general assessment methods. If the alignment was reached between the LO and the general assessment methods, it was then possible to define implementation strategies using assessment tasks. After reaching a classification system for the assessment methods, the following step was to associate to suggest implementation strategies using assessment practices.

Table 5 - Suggestion of implementation of assessment methods using learning tools

	MCQ	SAQ	Essays	Practical case	Problems	Reflective
Animation				x	x	
Audio			x			x
Chat discussion				x	x	x
Computer based test or exam	x	x	x			
Concept maps			x	x	x	x
Diagram			x	x		
Discussion forum		x	x	x	x	x
e-portfolio						x
File upload		x	x	x	x	x
Game					x	
Remote lab				x		
Simulations				x		
slideshow		x	x			
Video			x	x		x
Virtual lab				x		
Wiki			x	x	x	

From the analysis of Table 5 it can be concluded that these are suggestions for possible use of different types of learning tools that could be assessed by different types of methods. The justification for this match is based purely in practices and in existing tasks derived from literature research and from the case studies analyzed.

5. Alignment of LO and Assessment

The concept of aligning learning outcomes (LO), learning activities and assessment is explored by several authors [9], [10], [23], [26]. As Biggs explains this means that the teaching methods and assessment tasks should be aligned with the learning activities expressed by the intended or desired learning outcomes (LO). In the work of Bloom et al [23], the concept of alignment is also present. In their view, the educational goals should be used to shape the curriculum, guide instruction and provide specifications for the definition of evaluation instruments, techniques and methods. For each class and sub-class the taxonomy provides examples of questions to assess that specific LO. In the revised version of the taxonomy, Anderson et al have a practical approach to the concept of alignment. In this work, alignment is the level of correspondence between objectives, instruction and assessment. As already referred, this was the tool chosen for this work both for the definition stage but also, for the alignment component.

The conceptual model ALOE [27], proposes the alignment of assessment with LO by overlapping the rBloom matrixes produced and looking for matching cells. Even though this is an apparently simple procedure, several issues were found related with the application of the model. When matching Bloom's matrixes of LO assessment and LO, it is possible to look for a match for each individual cell or to look at the general matrix and look for the best match possible. Complexity rises when it is considered that for one individual LO one might have not only one assessment method but also a combination of methods. On the other hand, one might have a combination of LO that might have a match on one single assessment method or a combination of assessment methods. Both situations occur at course level, when we have several LO that are assessed in a single essay. Also we might have a single LO that will be assessed using a test and a practical case. The model ALOE is prepared to answer these and other questions.

After developing the conceptual model and reaching a final version of ALOE, it was applied to several case studies to test the potential for implementation. For the implementation stage it was necessary to translate the model into practical tools that could be used by the stakeholders. The conceptual model ALOE was used to structure a relational database that include the following components:

a) Reference on assessment: detailed description of the general assessment methods
b) Reference on Engineering education: detailed description of the engineering qualification frameworks
c) Information about the case studies:
d) General contextual information
e) Detailed description of LO
f) Detailed description of assessment and e-assessment

The database of ALOE was complemented with a workflow diagram for the analysis of the case studies in terms of alignment. Two scenarios of implementation were considered: verification of current alignment and improvement of alignment using suggestions for assessment methods. Implementation was tested using eight case-studies from different fields in engineering education. As indicated above, for each case study, the information was collected using documental research and interview with the faculty member responsible for the course. Each intended LO was analyzed in detail and mapped to the LO matrix. The same procedure was done to each assessment method. Each individual exam question, problem, project was analyzed and mapped to the rBloom matrix. To verify alignment, matrixes were compared. The results of the case-studies were discussed with the teachers.

6. Conclusions

Assessment of student learning is a complex field of research. Assessment and learning are deeply contextualized processes and it is not possible to have a solution that fits every case. The model ALOE intends to provide a flexible way to guide teachers and institutions the achievement of a better alignment at course and at program level. ALOE is by no means a closed system. It is possible, and even expected, to add or improve the model in terms of assessment methods and of learning outcomes in engineering education. Other professional qualification frameworks, besides ABET and EUR-ACE, may be added allowing testing for alignment to those specific LO. Also, by including the LO of a program and of the corresponding courses it is possible to test the internal alignment of the full program. This could be useful and relevant for accreditation processes and quality evaluation activities of EE.

In terms of the teacher activities the ALOE model can provide support at the two levels when preparing the course teaching activities and planning. The first level of influence is related with the definition of a file for each LO or competence that students need to acquire. The ALOE model can provide options for assessment tasks that can help the evaluation of the student for that particular LO. That can also be provided to the student allowing a clear perception by the student of the usefulness of each evaluation activity. The second level of support for the teacher is the definition of learning activities that will foster the acquisition of that particular competence. That may be helpful to compare with other similar courses in terms of solutions aiming at similar competences. That can provide useful benchmarking when comparing final and partial grades of the students in different courses and contexts.

ALOE is an organized and structured attempt of providing a model to define an understandable and rational mode of evaluation learning given a desired goal in terms of LO. Content provision has been in the past the main rationale for ensuring proper education and training. The model ALOE is independent of the content but it is related with the outputs of the learning activities. That is difficult but may be the proper approach to progress in terms of quality and of reliability of Engineering Education.

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A Theoretical Semantic Web Framework for Developing Learning Content

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Abstract

A Semantic Web (SW) is a technology based on ontology. This ontology defines knowledge representation or a set of knowledge terms. It contains vocabulary, semantic interconnections, rules of inference and logic for some particular topic. Current data mining relies on human interaction and ad hoc approaches to selection of documents for a given search criteria. When developing content for specific subjects or areas we involve activities such as searching, gathering and organising the same content and then present it to learners in a pedagogical manner. These activities must not be semantically compromised if we are to develop relevant and precise content for the learners. The current World Wide Web (WWW) has become inevitable as the source of content for specific subjects or courses but then it presents challenges as the content is not semantically interpreted by machines. This makes it difficult to deal with vast resources for content development because developers cannot get precise and relevant information during content searching, gathering and organising. The searches are not very accurate and content development has become a complicated process. In this paper we discuss the SW technology and envisage a possibility of simplifying learning content development for authors, lecturers/teachers and learners for any academic institution. The SW technology enables accurate search and semantic interpretation of learning resources by machines. We also propose an architecture that depicts the role and interaction among knowledge engineers, authors, lecturers/teachers and learners.

Keywords: *Semantic Web, Ontology, content, learning resources, learners, authors, lecturers/teachers, knowledge engineers.*

1. Introduction

The current World Wide Web (WWW) is a tool that shows some strength in the spheres of research and education. Though good enough to support and facilitate the development, delivery of teaching and learning content, its utilisation is somehow hampered by inability of users to navigate the vast and huge resources to get precise and relevant information meeting their requirements. The WWW is based on documents written in hypertext mark-up language (HTML), a mark-up convention that is used for coding a body of text interspersed with multimedia objects such as images and interactive forms [1]. Links are numerous, one way and can be removed or modified. Users look for certain information or want to complete a task but in many instances web searches still come fruitless and this frustrates [2]. As a result, current searches and retrieval processes involve a human loop and ad-hoc approaches to selection of precise and relevant learning material. So, the WWW lacks expressive data structures. There is no information discovery, no semantic processing and information is dependent on search engines which harvest data from indexed pages presenting this in a ranked format to the leaner or user. Protocols do not provide standardised search instead, they just traverse the links. These links do not present explicit semantic information to inform the users about the relevance of the information [3][4]. The complexity of the WWW presents challenges when it comes to content development hence the motivation towards the development of the SW framework that simplifies and facilitates learning content development.

2. Semantic Web

A SW is a web of data where the said data resides in databases, web pages or spreadsheets. It is presented as a linked directed graph with resources referred to as labelled nodes and relations as labelled edges. It provides a framework that allows information resources to be shared and reused thereby facilitating learning content development. To present information on the SW and make it become syntactically and semantically interoperable across applications we derive and adapt a layered framework to include, eXtensible Markup Language (XML), Resource Description Framework (RDF), Ontology and logic layers [5]. XML consists of XML declarations, XML schema and XML document data. XML declaration specifies the version and the encoding being used. XML schema constrains the structure of the XML document data. The RDF is a framework for representing metadata syntactically [6] [7]. Metadata is information on titles, authors and their affiliation, content data, the status of the work, the language used, the number of figures and tables, number of pages, the abstract and keywords.
It consists of a set triples (Object, Attribute, Value) which are semantic units used to describe the relationship between data as shown in table 1 and figure 1 below.

Table 1. Set of triples for RDF model

Object	Attribute	Value
It describes a resource such as; *http://www.researchgate.net/profile/Sibangiso_Ngwenya/*	We specify the creator or property such as; *Name of author* *Author contacts*	Specify the resource values such as the text; *sibangiso ngwenya* *00263772853209*

Table 1 shows the set of triples for RDF model where an object describes a resource of information, attribute specifies the creator or property such as name of author and his/her contacts while the value specifies the resource contents. Figure 1 presents the relationships that exist as described in the table above.

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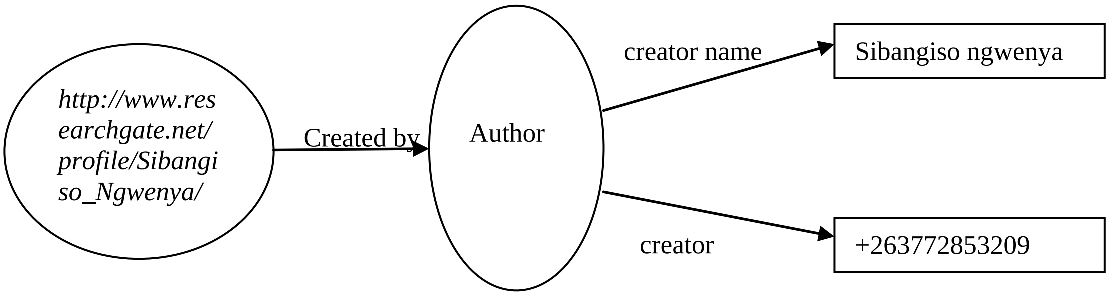

Figure 1. RDF model directed graph.

The other component is an ontology which forms a set of knowledge terms or vocabulary used to describe the domain [7] and is represented using an ontology representation language build on top of XML and RDF, such language as Web Ontology Language (OWL) released by W3C in 2004 [8]. We envisage the language as a standard in the implementation of the SW framework for the development of the learning content as it has well defined meanings that would define terms and their relationships. As for the tools, we use integrated, graphical ontology authoring tools such as Protege, Ontology Inference Layer(OIL) and OntoEdit.

Ontologies would play a very significant role of presenting vocabulary, the semantic interconnections and rules of inference and logic for some particular topic. In their implementation they standardise and provide semantic mark-up to content so that it can be interpreted and developed according to some particular domain. The semantic mark-up tells us about the presence of a particular entity in a number of classes. It also tells us that an entity has a particular property of which some entities have relationships among or between themselves. It is also derived from the semantic mark-up that descriptions from different people may refer to the same entity [9]. Ontologies are therefore knowledge representation frameworks describing the area of knowledge by defining the common concepts of a domain, the properties of the concepts and their relationships. Since an ontology is text based, agents traverse it for services, content development and information retrieval. For the learning content development we require the implementation of the SW that extends the current web so that agents are able to search and retrieve content semantically.

Through these ontologies, we define knowledge space as comprising of knowledge types, representation format and purpose of the represented knowledge. This knowledge is organised in terms of subject learning content, instruction and learner. Learning content are building blocks of a learning programme and the subject specific knowledge describes the subject related aspects of the content. From a pedagogical point of view, instruction is there to describe the educational aspect of the learning content while the learner is on the user knowledge side where characteristics, preferences and past learner behaviour are described. The purpose of the learning content tells us about the functions which are supported. Terminology definition and classification supports browsing and retrieval of learning content. Relationships between terms constrain the use of vocabulary while the model of a domain supports modelling of a subject area with logic supporting reasoning within a knowledge domain.

From a mathematical point of view ontologies provide a solution to learning content development, with precise and relevant access, representation and retrieval of information taking cognisance of relations that exist between concepts/terms in an ontology domain. On the SW there is inference among ontology objects with transitive relations where if A and B are sets we have, $A \subset B$ and $B \subset D$, then $A \subset D$. This means information providers relate the information to different ontologies, describe the content accordingly and user queries are then mapped onto them.

From a conceptual ontology view point, we also assumed that for all concepts C there exists conceptualisation Cs, such that the domain of C influences Cs, so that for every C, the Cs by a domain expert should have a 1:1 relationship. This is what the SW addresses but in the case of the WWW we observe ambiguity. Thus if C implies Cs the mapping is 1: many, then there exists a degree of ambiguity.

For cross domains say C again, there can be a 1: many, mapping of C to Cs, where the taxonomy of C limits the interpretation of Cs. The taxonomy of C which is the ontology in this case solves the problem of ambiguity for C and Cs. So C should not have more than one Cs in a single domain if and only if C is the terminal child of Cs. The taxonomy of C assumes a hierarchical list Cs and its relationships.

The WWW scenario makes us conclude that the current content is static and lecturer/teacher based. The SW presents machine readable content, where agents and applications access heterogeneous resources. Currently, there is scarce SW content available for agents and applications to access, process and integrate for purposes of learning content development.

Wrapper technology has been used to try and improve the current web. This technology has been used to extract relevant information from websites using heuristics, but then the drawback is that the technology cannot process information semantically and there is need to update it with website changes. The SW is there to support free navigation of semantically linked content presenting precise and relevant information to the users.

3. Research Method

This research followed a creative design methodology that involves a combination of literature survey for eliciting the design requirements and conceptual design for modelling the proposed learning content development framework. In this methodology we seek rational methods of incorporating scientific techniques and knowledge into the design process [10]. The methodology enables innovation that has user centred models for application development to meet end-user needs. The main technique used is value proposition and contextual design with the purpose of contextualising and appreciating user needs. The research framework is structured in a manner that the user insights are placed between the problem and solution. Thus the innovation occurs with the limits of the appreciated user's contextual setting.

The outcome of this research method was an integrated approach that focused on collecting user insights on learning content development from literature survey and translating them to a model learning content development framework for the SW.

4. Learning Content Development

Content development is a process of researching, writing, gathering, organising and editing information for publication and learning purposes. We consider content development as a participative activity involving domain knowledge experts, content authors, lecturers/teachers and learners. Domain knowledge experts deal with content, instruction and learner related knowledge while authors organise content into units including presentation of personalised content. The lecturer/teacher packages and assembles content as courses, including packaging of units, interoperability of learning content, organisation and sequencing of learning objects. Once the content is available the learner can then use the material in different forms such as resource sharing, reuse, annotation and discovery of learning objects through metadata. But then content assimilation and application depend on the delivery instructions and learner ability.

Our proposed architecture carefully addressed these tasks by providing custom agents that can be delegated and assigned the common or repetitive routines involved in each task respectively. In the SW architecture, intelligent agents make use of ontologies to perform logic based inferences and proofs that circumvent the limitations of conventional information systems architectures and WWW architectures.

The ultimate process of delivery of content involves all stakeholders as we indicated before, that content development is a participatory process. It involves authors profile manager, lecturers/teachers profile manager and learners profile manager. Utilisation involves lecturers/teachers profile manager and learners profile manager as shown in the framework in figure 2. They all interact in the learning process and activities to fulfil the goals and objectives of learners.

4.1. Learning Content Development Framework

There are vast sources from which lecturers/teachers harvest the material to be included in the learning content for a particular topic [11]. The ubiquitous nature of the information sources requires an architecture that enables applications that offer a wide range of content services, allowing the creation of diverse learning resources and different types of learning controls.

The proposed SW architecture illustrated in Figure 2, permits ontology annotation on content that are machine readable. This enables agent processing and seamless access to heterogeneous resources through semantic protocols. Agents are software programs that reason using knowledge derived from ontology annotations [13]. Repetitive task and decisions can be delegated to the agents. The semantic protocols are incorporated to aid agents in their reasoning when collaborating and during communication with each other. These agents process and integrate the content producing a precise, relevant and valuable learning output for the learners/users. The content is annotated according to domain ontologies which define the meaning of words or concepts appearing in particular content or document. The architecture also permits user interfaces that depict the role and interaction among knowledge engineers, authors, lecturers/teachers and learners. In this way, we overcome the current limitations of architectures bases on the current World Wide Web such as:

- Static and lecturer/teacher based learning content
- Navigation limitations
- No information discovery
- No semantic processing
- No expressive data structures
- Static irrelevant information from huge sources

- Dependence on search engine/indexing
- Traversing hyperlinks without semantics

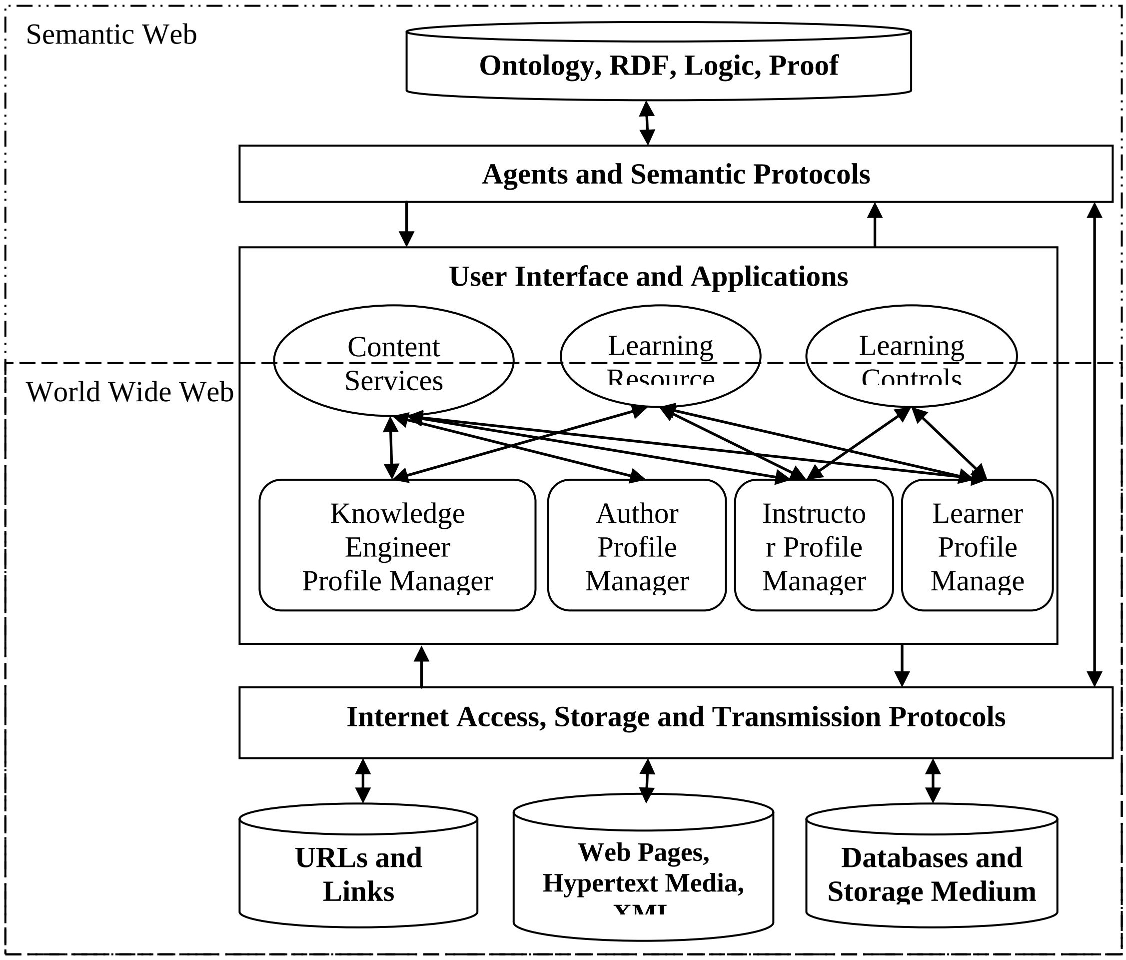

Figure 2.The learning content development framework.

As depicted in the proposed learning content development framework above, the current web is used to provide infrastructure for e-learning resources in the form of URLs, links, WebPages, hypertext media, XML, databases and storage medium. The URLs are the pointers to the machines used to host the related e-learning software. The e-learning software on the host machines allow the creation of WebPages, Hypertext Media and XML which are a representation of the content used for e-learning. The WebPages are easily viewed on any browser to present information from hypertext media which may be structured using XML. XML is an abstract data and document structuring format that would allow content to be combined from granular units to learning objects that suit the needs of teachers or learners based on concepts and their dependencies organised in an ontology. The XML and XML schema provide syntactic interoperability for an ontology definition and is machine readable. It transports structured documents across the web.

Links provide the traversal path from content to content within the host. XML is platform independent and is used to structure all the e-learning content on WebPages and Hypertext media for interoperability. Content that is durable or shared between many users is stored in databases and other storage media. The use of databases and storage medium save as repositories to store documents and user profiles. In order to access, store and transmit this e-learning content, the current web offers internet protocols used by different user interfaces and applications designed for e-learning. Protocols such as User Datagram Protocol (UDP), Transmission Control Protocol (TCP) and Internet Protocol (IP) support transmission and storage of information. These protocols allow any data to be transmitted between different devices and environments for access and storage.

However, the current WWW presents a number of content development limitations mentioned above. These limitations are circumvented by the addition of new layers on the current WWW to form the SW. The new layers are derived from the SW architecture [12] and adapted to e-learning. The SW embeds resources in the form of Ontologies, RDFs, Logic and Proof rules through which we facilitate machines to semantically read and process content which the WWW could not do. The semantics allow computing with precision and relevance with the aid of agents that perform tasks as delegated by humans in content development. The user interfaces and applications designed using the proposed framework take advantage of the semantic and agent technologies. Their different modules such as knowledge engineer manager, author profile manager, instructor profile manager and learners profile manager account for the different roles and interactions defined at institutional levels. These roles enable the human users to perform interaction aided by agents within the application services such as Content Services for the creation of content, Learning Resources for organising domain content and Learner Controls for learner activities and processes. This technology enables accurate search of learning resources and simplifies learning content development. However, it is important to note that learners have preferred patterns or methods of learning and these should be supported by the proposed framework. Learners would be able to semantically access images to cater for visual learning styles. Also supported are linguistic based learning, Mathematics based learning, Intra personal and Inter personal learning styles but then these depend on the availability of the content developed in accordance with different ontology domains and requirements of the learners.

5. Discussion

The proposed framework simplifies learning content development for authors, lecturers/teachers and learners by improving content search navigation and information discovery. The introduction of semantic processing and expressive data structures means that content development processes are no longer static and dependent on the instructor and search engines. In this paper we focussed on a theoretical framework and basic aspects involved in the development of content using the SW technology that reduces the retrieval of irrelevant information from huge sources. We discussed the components of the framework that aid in the development of learning content and the actors in the development process.

However, it is important to note that the SW and ontologies come with some challenges. We may have content unavailability, therefore, it is necessary to make the content available together with domain ontologies for the implementation of the SW technology. Application multilingualism is a challenge in the implementation of the SW. There is need to provide a facility that would allow access to information in several languages without depending on the native language of content providers and users. This would enable language independency in the development and access of learning content. Apart from that, services and tasks on the SW must be performed or rendered in a scalable manner as the SW grows bigger. The implementation of the proposed technology may mean cost in terms of time and money. In our implementation, we would require good infrastructure (hardware and software) to access the SW content.

The framework is a step towards improving content development in the area of education. Turning the WWW into a SW improves the process of searching, researching, writing, gathering, organising and editing information for publication and learning purposes. Users are presented with precise and relevant information instantly without wasting time on the Web. The benefits that come with the framework are vast, one on them being that, there is semantic interpretation and retrieval of the content. It’s also obvious that the lecturers/teachers cease to be the keepers of knowledge instead, they become real facilitators. There is a step towards the translation from homogenous and static content to dynamic content, even from a passive learner to self – oriented learner, and from classroom lectures to SW learning content.

6. Conclusion

We have presented a theoretical SW framework that facilitates and simplifies the development of learning content based on ontology technologies. We also covered the roles played by learners, authors, lecturers/teachers, knowledge engineers in content development process. The framwork points out the enormous potential of making learning content machine readable and semantically processed. In the framework, the knowledge engineer profile manager defines content services and resources for author profile manager, instructor profile manger and learner profile manager. The instructor in turn organises resources and packages them into subjects/courses or topics which are then used by the learner profile manager, thus providing a new semantic mechanism for developing learning content. It supports precise and relevant content searching, gathering and organising. Software agents are used in the gathering of learning resources and help in the development of content. The paper envisages that with increased development and availability of ontology tools, researchers will take up a challenge of developing ontologies in other areas of domain experts. This could make a difference in the subsequent generations to adapt these ontologies to match needs of knowledge engineers, authors, lecturers/teachers and learners. The number of documents that are machine readable would definitely increase making a big step towards the SW utilisation.

While we note the novel development of our framework, it important to highlight the fact that more work has to be done in the development of domain ontologies so that they are incorporated into the implementation of our framework. The proposed framework would capture and incorporate learning content, instructions, learner related and metadata aspects so as to support learning technology systems. The framework would also help us structure and explore the different applications of ontology technologies especially in the area of content development. However, our approach does not impact directly on the quality of content, though the benefits are noted in extended availability and access to semantically developed content, with lower educational costs.

Immerging from our discussion is the fact that the relationship between knowledge and content become explicit when using the SW and ontology technology in the searching, writing, gathering, organising and development of content for learning purposes. These technologies come with sharing and reuse of learning resources in different context and environments. We also note that currently, there is not much that has been done in the area of domain ontology development in specific subjects or courses. However, the SW and ontology technology for content development have been exploited successful to some extent, though some promises by these technologies remain unaccomplished.

We recommend that content developers use available SW and ontology technologies for content development to improve teaching and research. This would cultivate and bring about the appreciation of the SW for e-learning systems. The other important future development would be to migrate e-leaning sites to semantically configured systems to facilitate teaching and content development processes. Above all, the SW technologies facilitate evolutional and gradual improvement of content development providing support to knowledge engineers, authors, lecturers/teachers and learners.

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Onscreen marking: An effective assessment tool for engineering education in the information age

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Abstract

This paper presents an effective assessment tool, termed onscreen marking, which has been mandated by the largest open distance learning institute in South Africa, namely the University of South Africa (UNISA). Onscreen marking exhibits a number of benefits over the traditional way (marking hardcopies of written assignments) of assessing student written assignments in engineering, which include less paper and ink wastage, no postal costs, rapid turn-around times and punctual student feedback. Some challenges also exist (academic resistance to change, slow Internet speeds, server system downtimes and lack of training) which are discussed in this paper. Emphasis must be placed on the fact that academics need to undergo a paradigm shift with regard to assessing the ever-burgeoning supply and super-quick transmission of information in the current information age!

Keywords: *Onscreen marking, telecommunications, open distance learning, written assignments*

1. Introduction

"It is not the strongest of the species that survives or the most intelligent that survives. It is the one that is the most adaptable to change" [1]. These words by Charles Darwin indicate that change is inevitable and must be embraced if continuous success is to be enjoyed. Change is found in all spheres of society today, including higher education. Changes in teaching strategies, curriculum designs, assessment plans and student profiles are but some of the aspects that have undergone radical change in higher education globally. Added to this is the advent of the "information age".

The "industrial age" was connected with telegraphy, telephony, radio broadcasting and mechanical automation while the "information age" relates to computers, the Internet, mobile phones, broadband and wireless communication [2]. The "information age", within higher education, can often be equated to educational technology which may be broadly defined. It cannot be confined to the use of audio-visual aids, software packages and hardware equipment nor be limited to the use of psychological principles and instructional theories for bringing improvement in the process of teaching and learning [3]. It encompasses any technologically based technique which may be used to complement, enhance and not replace, traditional teaching and learning techniques in an attempt to improve student academic success [4, 5]. Student academic success is defined as students who successfully pass a course with a final mark of 50% or more. However, a major problem which still exists in many universities is that academic staff resist using educational technology in teaching, communication and research [6]. This is often attributed to not knowing what is required, what is involved, what is expected, what the benefits are and what the processes are.

However, it must be stated that educational technology provides rich possibilities for teaching and learning and for extending and connecting the spaces and places of students [7]. Equal amounts of learning are often accomplished in less time using educational technology and is preferred by students when compared to traditional instruction [8]. Educational technology has also introduced a number of effective assessment tools, such as online learning management systems [9] and onscreen marking (OSM) [10].

The purpose of this paper is to outline the OSM process as experienced by an academic in engineering education at one of the largest open distance learning (ODL) institutes in Africa, namely the University of South Africa (UNISA) which provides distance education to nearly 400 000 non-residential students [11]. The context of this study is firstly outlined and then followed by reasons for using OSM. The OSM process, as used at UNISA, is then described along with notable challenges.

2. Context of the study in Engineering Education

This study is limited to a telecommunications subject, termed Satellite Communication IV, which is a BTech module offered over a year period (approximately 8 months) at UNISA (see Table 1 for approximate time line and assessments). Electrical engineering students must be in possession of a National Diploma (minimum of 3 years to complete) before they can register for the BTech course which should be completed within two years.

Table 1. Time line and assessments for SCM4701 – Satellite Communications 4

Institution	University of South Africa		
Registration deadline	End of March		
Course material posted	Middle April		Weighting
Formative assessments	1 x multiple choice assignment	Due: 20 May	2 %
	First written assignment	Due: 30 June	9 %
	Second written assignment	Due: 30 July	9 %
Summative assessment	1 x venue-based written	October / November	80 %

The Satellite Communication IV syllabus covers four main sections, being orbital parameters, link design, satellite architecture and earth stations. Orbital parameters feature a number of mathematical calculations along with extensive application of acquired knowledge, and accounts for approximately 30 % of the final venue-based examination. The link design section considers all the gains and losses associated with a satellite earth station communications link, being one of the major singular calculations comprising approximately 25 % of the final venue-based examination. Satellite architecture considers access techniques, the platform, the payload and space environments. Earth stations present information relating to telemetry, tracking, control, amplifiers, reliability and availability. The last two sections (satellite architecture and earth stations) cover approximately 45 % of the final venue-based examination, where the interpretation of the information is assessed rather than its recall. Calculate, evaluate, determine, suggest and verify are typical verbs used in the final venue-based examination thereby placing particular emphasis on the use of Bloom's Taxonomy [12]. The final venue-based examination results in a written answer book which is kept for moderation purposes. The mark awarded to this final venue-based written examination tallies 80 % of the student's final mark, and is summative in nature.

The formative assessments, making up the student's year mark, needs to be submitted within approximately one month of each other, accounting for 20 % of the student's final mark. Formative assessments involve written reports where students answer predefined questions (set a year before by the examiner) based on the study guide and prescribed textbook. These formative assessments are designed to help prepare the student for the final venue-based examination. Students are assisted to understand the structure of an examination paper, and become used to the examiner's style of questioning. Students cannot encounter any surprises or different questioning styles in the examination paper, as this would prove unfair and unethical. Academics need to prepare their students to succeed in the examination paper, not to fail dismally. Preparing students for the examination paper includes timely feedback, which is one of the main benefits or advantages in using OSM.

3. Benefits from using onscreen marking

The benefits of using OSM may be summarised into five main points, namely time saving to students, cost savings to UNISA, less administrative work, possible improved student academic success and optimum usage of the software packages introduced by UNISA.

Saving time has become synonymous with the “information age”. People work at a pace never seen before in human history, as technology continues to speed up many processes, thereby improving globalization. The advent of OSM has especially contributed to cutting down on the amount of time that written assignments spend travelling around an educational system. The traditional way of submitting a written assignment is by post, which may take up to 25 days to return to the student, as shown in Table 2. This only occurs if there are no postal strikes! Early in 2013 a postal strike did occur, which caused a two to three week delay in written assignments being returned to the students. This negatively impacts on student learning which is very dependent on academic feedback provided in the written assignments! As students are not regularly in contact with academics, they need to get clarity on what they did right in their assignment, where they went wrong and how they can improve. Students need this feedback before they can submit their next written assignment, or they may find themselves repeating the same mistakes. Using the traditional postage system, with no postal strikes, would give the student 10 days to reflect on the first assignment in preparation for the second assignment. This does not bode well for academic success, as many UNISA students have full time employment and need to balance their academic studies with their secular responsibilities. However, when online submissions and OSM is used, then the approximate turn-around time is only five days. This affords the student 30 days to reflect on the first assignment in preparation for the second assignment, affording more time to rectify any deficiencies!

Table 2. Possible time lines for routing student assignments

Assignment submitted by post	Date	Assignment submitted online	Date
Student posts the written assignment	25 June	Student uploads the assignment onto myUNISA – official student portal	25 June
Assignment reaches the assignment department at UNISA	2 July	Assignment routed to the primary lecturer	26 June
Assignment department couriers the assignment to the markers	4 July	Primary lecturer routes assignment to the correct marker	27 June
Markers receive the assignment	6 July	Assignment marked by the marker	28 June
Markers return the assignment to the assignment department via courier	8 July	Assignment mark recorded on the system	29 June
Assignment department receives the assignment and processes the mark	10 July	Assignment returned to the student who reviews the comments / feedback	30 June
Assignment posted back to the student	12 July		
Student receives the marked assignment and reviews the comments	20 July		
Total Time	25 days	Total Time	5 days

Cost savings have become paramount in recent years with global economic recessions. The use of OSM results in a number of cost benefits to UNISA, especially in terms of postage and courier costs. UNISA supplies students with a “C4 without a window” postage-included envelope (approximate cost is R8.00 per envelope) for mailing their written assignments. The current number of student registered with UNISA is just below 400 000 (see Figure 1). Consider for a moment that only 10 % of these students submit a written assignment via the post office. This means that 40 000 assignments are submitted in an envelope that costs R8.00 each, resulting in a total cost of around R320 000. This is only for assignment

1, with assignment 2 to follow. That doubles the postage costs to R640 000. These costs would be eliminated if the 40 000 students submit their assignments online. Added to these postage costs are courier costs. SkyNet courier services are contracted by UNISA to courier assignments and examinations to markers and then back again. In 2010, the economy express cost (delivery within 48 hours) was set at R25.00 per kilogram for up to 5 kilograms. Consider, for example, that the 40 000 assignments that were discussed in the previous paragraph must be routed to 400 markers, each one receiving 100 assignments each. This means that the total cost to courier assignment 1 to the marker will be R10 000, which then doubles when the courier collects the marked assignments to return them to UNISA. The total approximate cost savings for submitting 40 000 assignments online therefore amounts to R660 000!

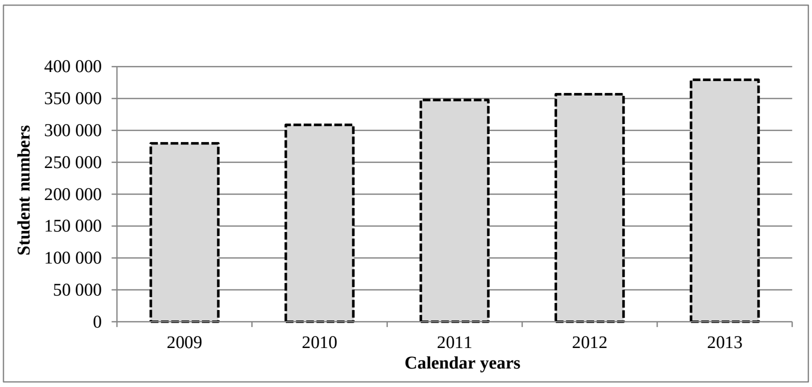

Figure 1. Growth of students at UNISA

Less administrative work (academic and administrative processing of marks) also results with the use of OSM. The traditional way of marking at UNISA involves separating the assignment from a pink docket covering page, where the module's and student's details are recorded. This docket covering page must be completed by the marker using a pencil to colour in specific numbers representing the student's final mark and the marker's personnel number. The docket covering page needs to be attached again to the assignment once it has been marked. It is also advisable for the markers to record the student number and mark in an EXCEL sheet on their computers, in case the written assignments are lost in the postal system. The assignment department, at UNISA, again separates the docket covering page from the assignment, and uses it to record the student's final mark on the system. It also serves as proof that the marker completed the work, thereby enabling a financial claim to be submitted to reimburse the marker. All this separating of docket covering pages, colouring in of numbers and recording of final marks is eliminated with OSM.

Possible higher rates of student academic achievement could be achieved by using OSM. The current success rates are shown in Figure 2, which fluctuate considerably from almost 60 % to little more than 30 %. This could be attributed to late feedback from academics, as students have very little time to reflect considerably on their assignments. This could lead them to not really identifying their mistakes or not even understanding the structure of the coming venue-based examination or the questioning style of the examiner.

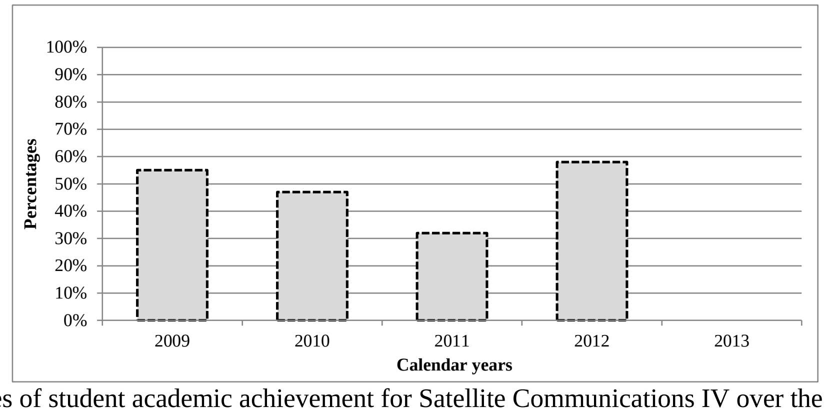

Figure 2. Rates of student academic achievement for Satellite Communications IV over the past few years

Optimum usage of the relevant software packages purchased by UNISA becomes possible with OSM. Investing in these software packages requires substantial funding, with return on investments only becoming possible when all academics buy-into this effective assessment tool for assessing student learning at an ODL institute.

4. Procedure to effectively use onscreen marking

The first step in effectively using OSM involves loading the Adobe Acrobat Pro software, along with the OSM tools which form an add-on to the main Adobe platform. The myUNISA comments software must also be loaded along with the J-Router, the main software program for routing assignments to lecturers, markers and students. Lecturers and markers login to the J-Router using their UNISA username and password. The second window to then appear is the module window, where the total number of modules allocated to a primary lecturer is shown (see Figure 3).

At times, many of these modules may be routed to the Chair of the Department, as some of the lecturers do not have the required software loaded or have not yet activated their modules for OSM. The desired module is visible, being SCM4701, along with the number of outstanding assignments for assignment 2, being 1 in this case. Selecting the appropriate module in the module window brings up the main window where the primary options are listed as tabs on the top of the page (see Figure 4). Details of the outstanding assignments may be viewed in the inbox. However, no movement or marking of these assignments is allowed as no marker has yet been selected. The assignments must therefore first be selected, and then routed to the correct marker using the “Selected Document” tab on the top of the page (“Route to” option). The correct marker’s number will now appear in the MARKER column.

Once it has been routed, then the marker can select his or her name in the marker selection box and the relevant assignments will appear in the marker’s inbox, but this time with the option to move the assignments to the workspace where the marking tool becomes available. This requires the selection of all the assignments, clicking on the “Selected Document” tab again, and then selecting “Put in workspace” (see Figure 5).

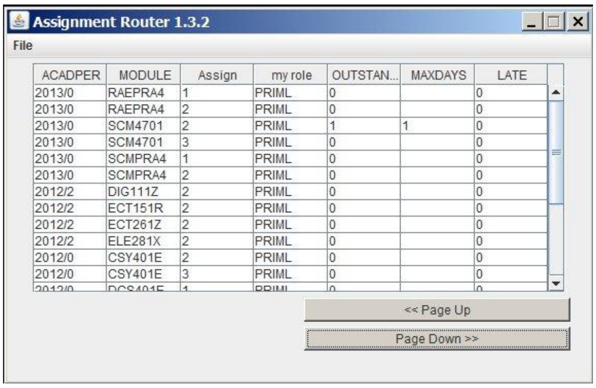

Figure 3. J-Router – Assignment Router – Module window

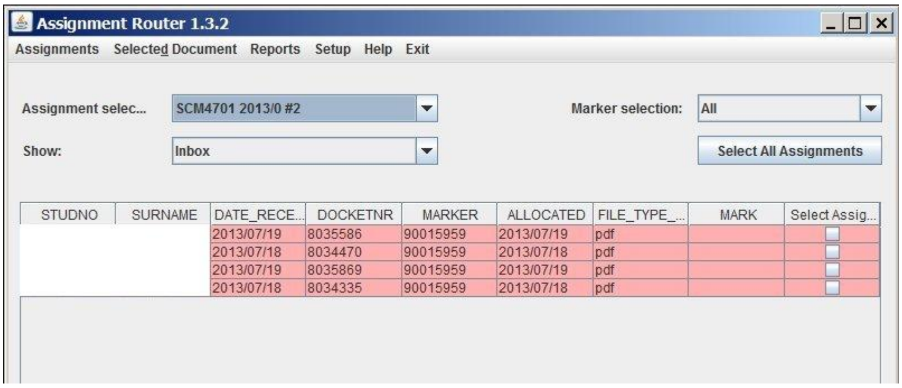

Figure 4. J-Router – Inbox with no marker assigned

All the selected assignments are then downloaded to a specific folder on the hard drive of the marker's computer. The marker can now access that folder (usually found under the "OnScreenMarking" folder in the C: drive) and open each assignment for marking purposes, even if the computer is not connected to the Internet. The "Open for marking" option is now made available on the J-Router, as can be seen in Figure 6. Other options which are also now available are "Retrieve into inbox" (move the assignment back to the inbox so that it can be routed to another marker), "Set mark" (capture the assignment mark on the system once marking is completed), "Put in outbox" (move the assignment out once it has been marked), "Replace with other document" (discussed further on in this section) and "Put on flashdrive" (move assignments to a flash drive for off-line marking).

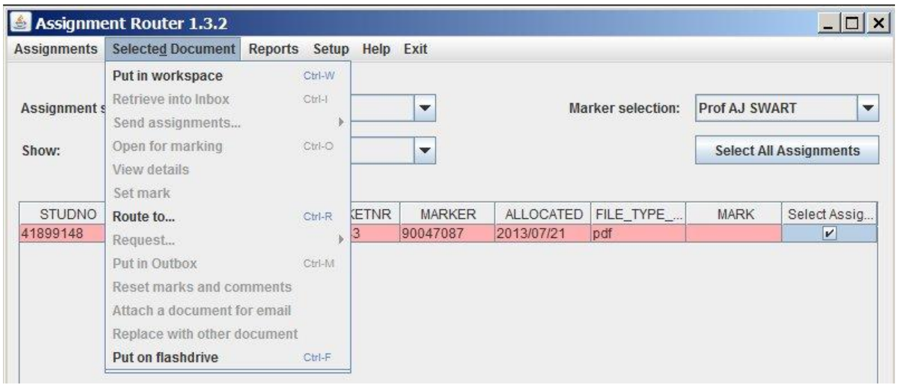

Figure 5. J-Router – Put in workspace available

The document needs to be in a pdf format, as Adobe Acrobat Pro forms the platform for the OSM tools (see top of Figure 7). An additional tool which is included is the myUNISA comments tool (visible on the left hand side of Figure 7). This tool enables markers to compile predefined comments which may easily be inserted into specific places in the assignment. This means that the marker does not need to re-type each comment for a similar mistake encountered in a number of assignments. The marker simply needs to select the "Comment Mark" tool in Adobe Acrobat Pro, place the comment circle (see Figure 7 for an example), copy the appropriate comment from the myUNISA comments and paste it into the comment circle. The value to this "Comment Mark" should be a zero! The available OSM tools further include half a correct tick, a full correct tick, a stamp, a wrong tick, a select cursor (used to delete a comment or inappropriate tick), a comments mark button (with a small e inside), a mark count button (used to set the total number of marks and tally the awarded number of marks for the assignment) and an info button.

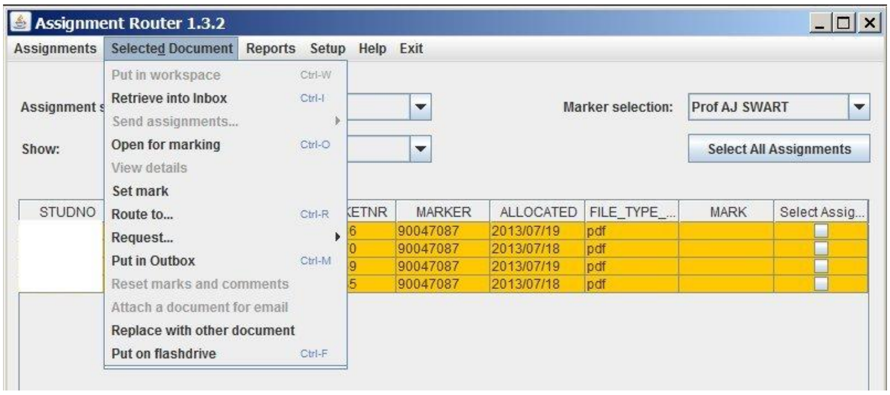

Figure 6. J-Router – Open for marking available

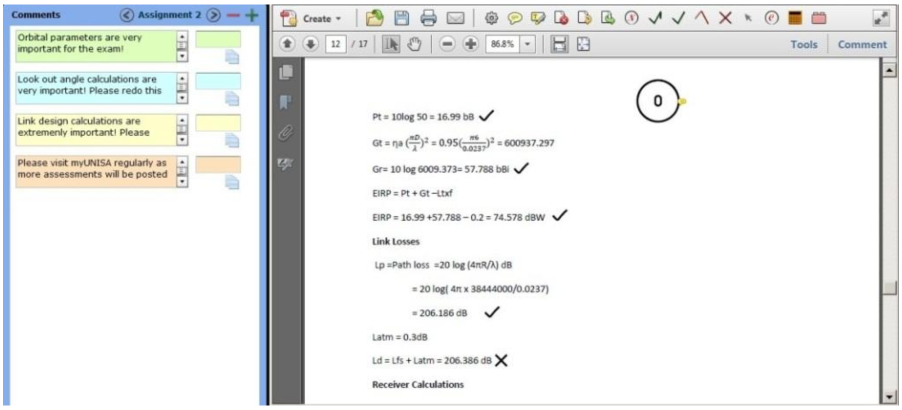

Figure 7. Adobe Acrobat Pro with myUNISA comments on the left hand side

Once the assignment has been marked and the mark count button selected, then the mark for the student is placed automatically at the end of the assignment. This mark is then entered into the system using the "Set Mark" selection in the "Selected Document" tab (see Figure 6). The next step is to select all the marked assignments and tick the "Put in outbox" option. Once the assignments are put into the outbox (which may take some time as the pdf documents need to be uploaded to the J-Router) then the marker can again "Select all Assignments" and move them to the next folder, being the "Sent to Students" folder. This is done by selecting the "Assignments" tab on the top of the page, selecting "Bulk Processing" and "Send assignments to Students" option, which then automatically routes the marked assignments back to the students (see Figure 8).

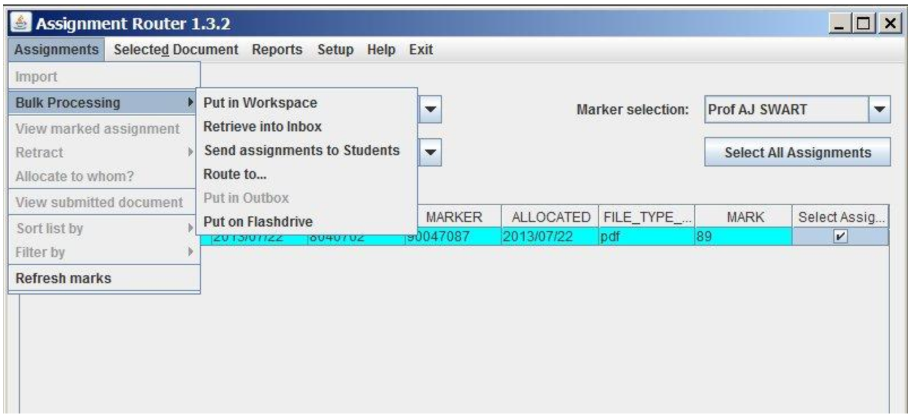

Figure 8. J-Router – Assignments to be "Sent to students"

At times students submit assignments as a docx file or a zip file, and not a pdf file (FILE_TYPE). This requires the marker to download the file to the workspace. The docx file then needs to be opened in the right directory on the main drive, and then converted to a pdf file before marking can occur. The marker then needs to replace the original .docx file with this newly created .pdf file for processing purposes (the Selected Document tab has an option entitled “Replace with other document” – see Figure 6).
Another problem which may arise is the submission of a corrupt file, which cannot be opened by the marker. The marker must, in this case, select the corrupted file and then click on the “Selected Document” tab, selecting the request and subsequent cancellation of assignment option. An appropriate reason must then be selected or entered for the cancellation request, being “Unable to open for marking” in this regard.

5. Challenges in using onscreen marking

The installation of the J-Router, Adobe Acrobat Pro, OSM tools and myUNISA comments software may take up to 5 hours to finalize. This is because different settings have to be selected and verified. The latest computer technology is also required, with Windows 7 being preferred as the minimum operating software. A relatively fast Internet access point is required (an ADSL line is suggested) to be able to route the assignments between the UNISA system and the markers computer. Adding to the challenge are external markers. UNISA makes use of many external markers to successfully meet the demands of 400 000 students. Some of these markers live 100 km or more away from the UNISA campus, and cannot just arrive on any day to have the relevant software installed. What is more, many of them do not have the latest technology available at home, maybe only having a work sponsored notebook. How does UNISA accommodate these markers and the student assignments which are meant for them?

The user friendliness of the J-Router is sometimes problematic. Routing the assignment from the inbox to the workspace may take a number of minutes, depending on the number and file size of the assignments. Moving from the first module window into the inbox window does not prove problematic. However, if another module to be marked resided on another page of the first module window, then the marker needs to exit the program and login again. Only then can he or she select the correct page where the other module to be marked resides. The entire process of routing then starts again. Is it possible for the software to be adapted to address this concern?

Internet access by students is problematic at times. UNISA caters to students all over Africa, including those living in rural communities. The only form of contact with the outside world is still the post office, as the telecommunications network must still reach many of these outlying and remote areas. Expecting these students to have a fast Internet connection to upload their assignments is unfair and unreasonable. At most they will have a standard modem connected to their telephone line for Internet communications. What is currently being done to enable more students to access the Internet at acceptable speeds?

Training of staff is another challenge which is experienced with OSM. A fellow colleague of the author wanted to have the relevant software loaded onto this notebook for OSM. The entire process took one day to complete, and then outstanding issues still remained. For example, the fellow colleague could not mark the assignments off-line. Would it not assist all markers if a tutorial could be written where the entire online process is detailed step-by-step?

Bandwidth limitations impact negatively on the system’s response time, especially when 40 000 assignments are routed around by markers. This is especially of concern when markers work from home, where they may have limited bandwidth due to limited financial means. Why could a service level agreement not be negotiated between UNISA and telecommunications network operators for lower connection costs for markers and students?

6. Future work

The actual time taken to mark an assignment onscreen should be determined, and then correlated to the amount of time it takes to mark that same assignment as a hard copy. The time taken to process the OSM assignment and the time taken to process the hardcopy assignment should also be determined to try and establish time efficiency.

This time measurement process should also be undertaken in other modules featuring different questions to try and establish differences or similarities. Different modules using long essay questions may put more strain on the markers eyes and concentration, than would a hardcopy assignment. Different marker feedbacks should also be obtained to verify perspectives and highlight specific concerns.

Finally, does the use of OSM contribute to a higher rate of student academic success? A time-lag study would be required to ascertain the answer to this question.

7. Conclusions

The purpose of this paper was to outline the OSM process as experienced by an academic in engineering education at UNISA. A detailed discussion of the process was given, from when the J-Router is activated until the assignments are sent back to the students. The OSM tools which exist as add-ons in Adobe Acrobat Pro were presented along with the usefulness of the myUNISA comments software package.

It must be emphasised that UNISA caters to a large number of distance learning students who rely on timeous feedback in order to prepare adequately for their final examinations. The use of OSM will facilitate faster turn-around times for written assignments submitted by distance learning students, who are not regularly in–contact with their lecturers on a face-face basis. This may lead to improved throughput and pass rates, as students have more time to reflect on the mistakes which they have made in their assignments, correcting them well in advance of their written examination!

A major problem does still exist in that many university staff members resist using educational technology in teaching, communication and research. However, given the specific benefits of using educational technology in the form of OSM of assignments at an ODL institute cannot be ignored. Time saving to students, cost savings to UNISA, less administrative work, possible improved student academic success and optimum usage of the acquired software packages were noted as possible benefits or advantages. On the other hand challenges are encountered, such as the installation of the software, user friendliness of the J-Router, Internet access by students, training of staff and bandwidth restrictions. However, emphasis must be placed on the fact that academics need to undergo a paradigm shift with regard to assessing the ever-burgeoning supply and super-quick transmission of information in the current information age!

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Engineering Education for economic sustainability

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Abstract

The national struggle for economic emancipation and sustainability by nations of the world is a struggle for a better tomorrow. Sustainability in the sense that the factors of development and production are over stressed and might not forever be available. As the world's population is growing at an alarming rate and the resource to provide social amenities is depleting slowly, urgent steps must be taken to avert this trend to avoid serious scarcity of resources to meet social demand. Engineering being the engine room of economic development must be given the desired attention. The Engineer of the 21st century must be adequately trained to face the millennium challenges, one of which is sustainability. The first issue to be addressed in this regard, the authors believe is the engineering curriculum which needs revision to reflect the millennium challenges. Therefore, this paper understudies the type of engineering training of the 21st century engineer for a sustainable economy. The paper takes a look at the engineering curriculum with emphasis on sustainable energy and power. The authors discovered that the present curriculum is silent on sustainability issues. Therefore, it is the aim of this paper to propose the revision of the engineering curriculum, to include technological innovation and sustainability. This will so equip adequately, the 21st century engineer, to be well informed to manage the present and future engineering challenges for a sustainable economy that guarantees a better future.

Keywords: *Trained Engineers, Energy and Power.*

1 Introduction

As the population of the world grows, there is need to strive for higher and higher standards of living without depleting the limited resources of Earth and its inhabitants. We may ask these questions: Will it be possible to balance the increasing human needs with a consideration of both the built and the natural environments? How can the engineering programmes and curricula be altered to include the issues and principles of sustainability? It is worthwhile to review the state of economic sustainability education in engineering for which the subject is now at the forefront of its learning objectives [1]-[2]-[3].The developing countries and their government have made frantic efforts to encourage engineering education. In Nigeria, effort was made to create efficiency in the education system in the mid 1980s, by introducing diversification and specialization of the universities with a view to increase their scientific, technological and agricultural contribution to the transformation of the country [3]-[4]. Sustainability being an indispensable tool in the development of various sectors of the economy should be the hope of the nation to develop and sustain development to attain its national vision and goals, be it Millennium Development Goals (MDGs), National Economic Empowerment and Development Strategy (NEEDS), Vision and the Seven Point Agenda [3]. This paper examines engineering education and provides the review for educational programmes in engineering and points out the possible applications of the experience from various universities that prepare professionals in this field, for sustainable national development and growth.

2 Role of Engineers in Economic Sustainability

Engineering educators must tap into students' passion, curiosity, engagement, and dreams [5]. When looking back over the years of the engineering world, it is realized that many things have changed remarkably, but others seem not to have changed at all [3]-[6]. Issues that have not changed include: how to make the freshman year more exciting; how to communicate what engineers actually do; how to improve the writing and communication skills of engineering graduates; how to bring the richness diversity into the engineering workforce; how to give students a basic understanding of entrepreneurial skills; and how to get students to think about professional ethics and social responsibility [3]-[5]. Forgetting the most part that things have changed in astounding ways. We have moved from slide rules to calculators to PCs to wireless laptops. Just think of all it implies [6]-[7].

Looking ahead and setting goals should be a "piece of cake." But to gain some perspective, look back and think about what was not going on in 1990, for example, there was no World Wide Web, and Cell phones and wireless communication were in the embryonic stage [6]. The big challenge was the inability of the Country’s manufacturing sector to compete in world markets [7]; Japan was trying to bury some Countries economically. The human genome had not been sequenced. There were no carbon nanotubes. Buckminster Fullerenes had been in America for about thirteen years they had not even begun to inflate the dot-com bubble, let alone watch it burst. So predicting the future, or even setting meaningful goals, is risky, even on a scale of a mere twenty three years ago. Years ago [8], a study of predictions of the future and one simple constant was found, underestimation of the rate of technological change and overestimation of the rate of social change. That is an important lesson for engineering educators [3]. We educate and train the men and women who drive technological change, but sometimes forget that they must work in a developing social, economic, and political context [6].

The next generation of engineering students will be facing the most exciting period in human history for science and engineering [3]. Exponential advances in knowledge, instrumentation, communication, and computational capabilities have created mind-boggling possibilities, and students are cutting across traditional disciplinary boundaries in unprecedented ways [7]. Indeed, the distinction between science and engineering in some domains has been blurred to extinction, which raises some serious issues for engineering education. Some developing countries like Nigeria has underinvested in engineering and physical sciences, and only nibbled around the edges of long-term energy supply and distribution problems. As a result, the engineering field has been marginalized from the perspective of many bright young men and women [6]. It seems that a situation similar to the one faced in the 1980s where the dominant manufacturing sector had become fat, sassy, and then, suddenly, uncompetitive is repeating itself. We need to recharge corporate entrepreneurial and academic Research and Development (R&D), as well as our curricula in energy [7]. We need to make energy an exciting, well supported, dynamic field that attracts the best and brightest young men and women and gives them opportunities to contribute through sustainable innovation.

As we think about the challenges ahead, it is important to remember that students are driven by passion, curiosity, engagement, and dreams [5]. Knowing exactly what they should be taught, we need to focus on the environment in which they learn and the forces, ideas, inspirations, and empowering situations to which they are exposed to [1]-[6]. Despite our best efforts to plan their education, however, to a large extent there is need to simply step back and watch the amazing things they do [7]. Alternatively, universities and engineering research institutes can create a conducive environment for creative adventure, demanding innovation and quest for sustainability in students and empowering them, could be more important than specifying curricular details. Many universities are leading the way by incorporating sustainability into their university vision, the surrounding community and their curricula [1]-[6]. Biologists and neuroscientists are suddenly rediscovering the full glory and immense complexity of even the simplest living systems. Engineers and computer scientists are suddenly as indispensable to research in the life sciences as the most brilliant reductionist biologists. The language in the life sciences today is about circuits, networks, and pathways. It is also fascinating to participate in discussions of the role of science and biology in R&D on homeland security, or, more generally, on anti-terrorism, which is as the "Mother of All Systems Problems [7].

Looking at engineering in the future and forecasting the type and quality of engineers, basic questions about future engineers are asked on: who they will be, what they will do, where they will do it, why they will do it, and the implication of these for engineering education in Nigeria and elsewhere. In the future, Nigerian engineers will constitute a smaller and smaller fraction of the profession, as more and more engineers are educated and work in other nations, especially in America, Asia and China. Universities around the world, especially in America, Asia and other Countries in Europe, are becoming increasingly utilitarian, focusing on advancing economies and cutting-edge research. Examining a delegation of presidents of American universities some years ago, among the Americans were Renaissance scholars, an economist, a political scientist, a linguist and a mechanical engineer, whereas the presidents of seven Chinese universities that had been chosen to be developed into world-class research universities, were six physicists and one engineer who had become a computer scientist This story illustrates the tectonic changes taking place in the way engineers are being produced and in where engineering and research and development are being done [6]. In 1998, Massachusetts Institute of Technology (MIT) established an Engineering Systems Division, which reflected a growing awareness of the social and intellectual importance of complex engineered systems. At the time, a large number of faculty members in the School of Engineering and other schools at MIT were already engaged in research on engineering systems, and MIT had launched some important educational initiatives at the master's and doctoral levels. The Engineering Systems Division, which provided administrative and programmatic coherence for these activities, was intended to stimulate further developments [6]-[9].

From the Nigerian perspective, globalization is not a choice, but a reality. To compete in world markets in the knowledge age, we cannot depend on geography, natural resources, cheap labor, or military might. We can only thrive on brainpower, organization, and innovation [1]-[7]. Even agriculture, the one area in which Nigeria has traditionally been the low-cost producer, is undergoing a revolution that depends on information technology and biotechnology, that is, brainpower and innovation.

3 Meeting the global challenges

Every sovereignty, mostly in the developing economies is faced with the challenges of adequate power and energy supply, supply of clean water, healthcare delivery, deforestation, global warming and climate change, etc. The authors believed that engineering often used to drive the socioeconomic development of any state, therefore, the methodology of teaching and learning engineering should be evaluated. The study evaluates engineering education in Nigeria using data from databases of the regulatory bodies – National Universities Commission (NUC) and the Council for the Regulation of Engineering in Nigeria (COREN). These data were then analyzed using descriptive statistics, which required ranges from academic contents – philosophy and objectives of the programme, curriculum content, admission into the programmes, academic regulations, evaluation of students’ work, practical and project work, standard of examination, and staffing; physical facilities includes: laboratories, classrooms, office, safety and environmental sanitation; funding of the programme and administration of school/faculty/department. Based on the performance of the programme according to the above criteria or performance indicators, the aggregate score is then used to determine the accreditation status as full or denied recently.

To succeed, there is a need to establish a proper intellectual framework within which to study, understand, and develop large, complex engineered systems. Discovery must be made of new scientific knowledge and technological potential through research and training, for example, individuals, agencies or corporate bodies establishing an endowment fund to encourage innovative engineering research. Organizing workshops and conferences for students, teachers and industries to showcase engineering innovations, is a good way to encourage hard work. To train and equip Engineers to function adequately beyond borderlines thereby participating in the global market, the present curriculum must be revised to include sustainability. If the present engineering curriculum is revised to reflect sustainability, it is possible that manufacturing with at least 80% local content, can start from Nigeria and spread to the developed countries like; the United States and others like; Taiwan, Korea, China or India. Meeting these challenges will require an accelerated commitment to engineering research and education. Research universities and their engineering schools will have to do many things simultaneously: advance the frontiers (scales associated with complexity) of fundamental science and technology; advance interdisciplinary work and learning; develop new, broad approach to engineering systems; focus on technologies that address the most important problems facing Nigeria and the world; and recognize the global nature of all things technological, especially renewable energy for the power sector.

4 Results

Table 1 below presents the collected data and the analyses of the results obtained reveal that only 21 (16.28%) of the engineering programmes got full accreditation. This is as a result of poor funding and thus poor educational infrastructures, deficiency in teaching and research equipment.

Table 1. NUC 1999/2000 Accreditation Status of Existing Engineering Programmes in Nigerian Universities.

Engineering Disciplines	No. of Universities	Accreditation		
		Full	Interim	Denied
Agricultural Engineering	13	1	10	2
Chemical Engineering	12	3	7	2
Civil Engineering	22	2	14	6
Computer Engineering	6	Nil	1	5
Electrical & Electronics Engineering	14	3	5	6
Electrical Engineering	8	1	5	2
Electronics Engineering	1	**Nil**	1	Nil
Food & Science Technology	13	2	7	4
Industrial Engineering	1	Nil	1	Nil
Marine Engineering	1	Nil	1	Nil
Mechanical Engineering	24	8	7	9
Metallurgical & Material Engineering	6	Nil	6	Nil
Metallurgical Engineering	1	Nil	Nil	1
Petroleum Engineering	4	1	2	1
Polymer & Textile Engineering	1	Nil	1	Nil
Production Engineering	1	Nil	Nil	1
Water & Environmental Engineering	1	Nil	1	Nil
Total (%)	129 (100)	21 (16.28)	69 (53.49)	39 (30.23)

Source: Extract of NUC (2000)

From the two frontiers of engineering, each of which has to do with scale and each of which is associated with increasing complexity. One frontier has to do with smaller and smaller spatial scales and faster and faster time scales, the world of so-called bio/nano/info. This frontier, which has to do with the melding of physical, life, and information sciences, offers stunning, unexplored possibilities, and natural forces of this frontier compel faculty and students to work across traditional disciplinary boundaries. This frontier meets the criterion of inspiring and exciting students and its outcome will be products and processes that will drive a new round of entrepreneurship based on things you can drop on your toe and feel the real products that meet the real needs of real people.

The other frontier has to do with larger and larger systems of great complexity and, generally, of great importance to society. This is the world of energy, environment, food, manufacturing, product development, logistics, and communications. This frontier addresses some of the most daunting challenges to the future of the world, renewable energy in the power sector. If the Government, engineering educators carry out their legitimate responsibilities without fear nor favor, these challenges will also resonate with the students.

5 Discussion

In the future, with the implementation of all the training and practice in national settings and in global corporations, including corporations with some head Countries like the United States. The developing countries will see engineering as a capable mover and driver of the economy, an exciting career, a personal upward path, and a way to affect local economic well-being. These mega shifts will occur faster and faster and will pose enormous challenges to future generations. Our companies already know this, but it often seems that the public and the politics are still largely in denial of this reality, a very dangerous situation. If realities of globalization are continually denied or, worse yet, retreat to protectionism, then the right things would not be done that will enable the society to partake and benefit from the global economy.

6 Conclusion

Setting the educational system in the path towards meeting the 21st century challenges is proposed in this paper. Engineers of today and tomorrow must be prepared to conceive and direct projects through innovative engineering of enormous complexity that require a highly integrative view of engineering systems. So far with the review of the curricula, suggestions have been made in this paper, that engineering students prepared for the future professional practice must be adequately trained to communicate and partake in the global economy. Engineers must be motivated even from their freshman year; must have an understanding of what engineers actually do; must write and communicate well; must appreciate and draw on the richness diversity; must think clearly about ethics and social responsibility; must be adept at product development and high-quality manufacturing; must know how to merge the physical, life, and information sciences when working at the micro- and nanoscales; and must know how to conceive, design, and operate engineering systems of great complexity. They must also work within a framework of sustainable development, be creative and innovative, understand business and organizations, and be prepared to live and work as global citizens.

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Presenter: The paper is presented by Muncho Josephine Mbunwe.

Engineering Education in the Information Age

Integrating Innovation Pedagogy and CDIO Approach – Pedagogic and Didactic Viewpoints

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Abstract

In this paper we discuss how innovation pedagogy and the CDIO approach are interconnected and how they, by facing similar challenges and by sharing very parallel goals and objectives, can help engineering education to develop to the needed direction. The similarities and differences of these approaches are discussed from pedagogic and didactic viewpoints. The CDIO approach can be strengthened by innovation pedagogy, which was developed in Turku University of Applied Sciences, and its objective to provide the students with innovation competences in order enable them to participate in the innovation processes in their future working places and develop them. We believe that innovative solutions are created through social learning in diverse surroundings and discuss the nature of boundary crossing in higher education and its ability to provide the different types of knowledge needed in innovation creation. The findings and the value of this paper extends the concept of knowledge in learning context to support the development of innovation competences by integrating the CDIO approach with innovation pedagogical approach.

Keywords: *innovation pedagogy, CDIO, didactic, pedagogic, boundary crossing.*

1. Introduction

The world surrounding practically any university all around the world is under a constant change. The rate of this chance accelerates on a speed never seen before. The availability of Internet has brought knowledge and information to the reach of everybody having access to the network. Every possible piece of information needed for educating high level professionals can be found in the Internet. However in the universities we still tend to educate the students with traditional methods meant originally for a world which is stable and emphasizes mainly learning of explicit knowledge. Methods better suited for a constantly changing world focus on activating students in learning and include also unofficial situations.

In all areas of knowledge creation, the demand for a broader perspective is increasing. We are facing issues and challenges, which are becoming more and more difficult to address within the framework of a single method, be that a discipline or a profession. Knowledge is claimed to be at the heart of innovation and that innovation typically emerges at the boundaries of different knowledge domains. A boundary crossing approach for instance in problem solving, service or product creation, research or organizational team work enhances creativity, and new previously unthinkable innovations are more likely to occur. The green book of EU makes a suggestion that in higher education the curricula should systematically include entrepreneurship studies in non-economic curricula. It also proposes that science students should be made to work together with business students.

Modern engineering education programs seek to provide the students with a broad base of knowledge, skills, and attitudes necessary to become successful young engineers. The CDIO approach is a worldwide collaborative to conceive and develop a new vision of engineering education (www.cdio.org). CDIO is based on a commonly shared premise that engineering graduates should be able to Conceive – Design — Implement — Operate complex value-added engineering systems in a modern team-based engineering environment to create systems and products.

A continuous interaction, in which breaking borders between different fields of knowledge and organizations is encouraged, and which encompasses all the actors involved, is a prerequisite for success. This is the challenge that innovation pedagogy, a learning approach that defines in a new way how knowledge is assimilated, produced in a manner that can create innovations, aims to tackle. In this paper we discuss how innovation pedagogy and the CDIO approach are interconnected and how they, by facing similar challenges and by sharing very parallel goals and objectives, can help engineering education to develop to the needed direction. The similarities and differences of these approaches are discussed from pedagogic and didactic viewpoints.

2. Learning and teaching according to innovation pedagogy

The role of education has traditionally been to give knowledge-based readiness, which later would be applied to practice in various innovation processes in working life. Innovation pedagogy introduces how the development of students' innovation skills from the very beginning of their studies can become possible. [1] Innovation pedagogy contributes to the development of new generation of professionals whose conceptions of producing, adopting and utilising knowledge make innovative thinking and creating added value possible. [2, 3]

The core of innovation pedagogy lies in emphasising interactive dialogue between the educational organization, students, and surrounding working life and society. In accordance to this its conceptual core can be divided, as figure 1 describes, into three different spheres in parallel to the three major actor groups benefiting from innovation pedagogy [4]:

- final learning outcomes, creation of innovations and produced capability to participate in diverse innovation processes – having primarily to do with students, who are expected to create innovations while affiliating with working life
- learning of innovation competences alongside with study programme specific knowledge, skills and attitudes – being mostly connected with working life, which provides students with ideal surroundings to acquire the competences needed in innovation processes and in future working life in general
- meta-innovations – referring to the necessary cornerstones needed for learning according to innovation pedagogy; the elements enabling innovation pedagogy to be applied, including methods of learning and teaching utilised in the learning processes by the faculty members together with the students enhancing both the creation of innovations and innovation competences.

The meta-innovations are essential requirements for innovation pedagogy to succeed and they must be developed and used so that the cornerstones of innovation pedagogy are enabled in the learning environment. The cornerstones include innovative learning and teaching methods, cross-disciplinary learning environment/boundary crossing, integrated and extensive research and development activities, flexible curricula, concentration of acknowledging the importance of entrepreneurship and service production and internationalization in the level of research, development and student engagement. The methods used target specially to contribute to the development or student's interpersonal and networking competencies.

Innovation competencies are the learning outcomes, which refer to knowledge, skills and attitudes needed for the innovation activities to be successful. The OECD's initiative to assess the feasibility of an Assessment of Higher Education Learning Outcomes (AHELO) maintains a clear focus on teaching and learning and identifies a wide range of factors influencing higher education. AHELO focuses especially on the assessment of student's individual competencies, such as critical thinking, analytic reasoning, problem solving and written communication. We believe that individual competencies do not assure alone that working life expectations are met. There is a need for more performance-related competencies [4], which we call interpersonal and networking innovation competencies. By defining innovation competencies, which include in addition to the individual ones also interpersonal and networked aspects we believe to be able to significantly give added value to AHELO and to the assessment of the targeted outcomes. The methods applied and the way how teachers and students interact constitute the basis for learning and thus enable the development of innovation competencies. The methods used also facilitate intuitive and unexpected learning during the learning process and make transmitting of tacit knowledge possible when dealing with working life. In innovation pedagogy this kind of learning outcomes can manifest themselves in the format of intuitive and tacit learning which takes place in the learning situation. They can be e.g. experiences on cultural differences, on working at customer surface etc. The core idea in innovation pedagogy is to bridge the gap between the educational context and working life. Learning and teaching processes are developed so that they provide improved competences for the students and enable personal and professional growth. Learning is deeper when the previously gained knowledge is continuously applied to practical contexts. [5]

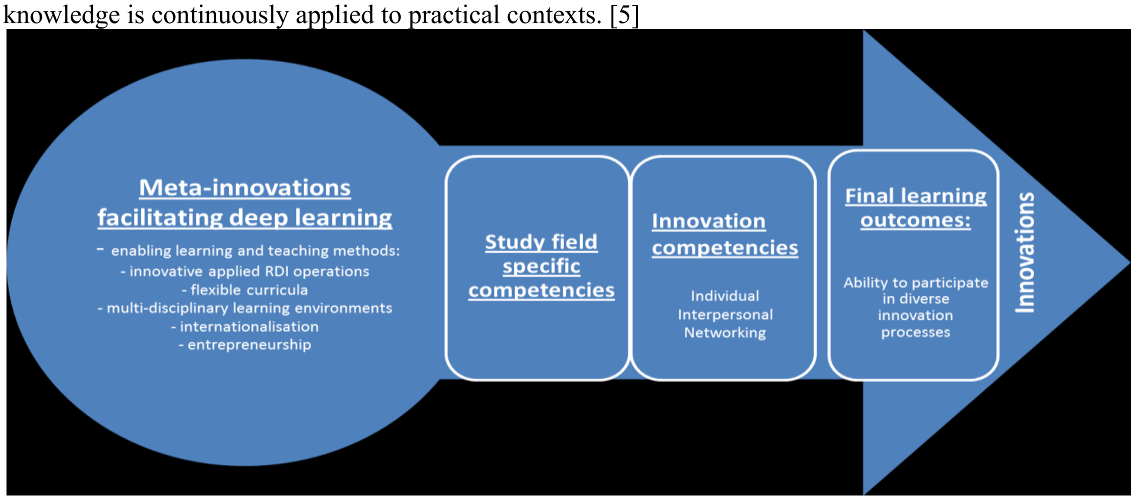

Figure 1. Methods, objectives and learning outcomes according to innovation pedagogy

In working life usually there are people from many different disciplines who are expected work effectively together. Equally also the tasks in working life many time require knowledge and skills which do not belong to the scope of one and only discipline. Boundary crossing during studies is one of the means to solve the transfer problem. When students get used to working with people from different disciplines and learn to accept that they have to be interested in subject matter belonging for many different disciplines transfer of knowledge at work place becomes easier. Innovation pedagogy believes that boundary crossing activities must form part of the everyday life of a student. According to its aims different methods must be developed so that all the cornerstones of innovation pedagogy can be found in the learning environment. Those methods should contribute especially to the development or student's interpersonal and networking competencies. These cornerstones include cross disciplinary environment, research and development activities executed by a big amount of students, flexible curricula, concentration of acknowledging the importance of entrepreneurship and service production and internationalization in the level of research, development and student engagement. [6]

3. CDIO approach – pedagogic and didactic cornerstones related to innovation pedagogy

The CDIO approach started in 2000 when a group of engineering educators identified the gap between the working life expectations and engineering education. A need to create a new vision and concept for undergraduate education was recognized and thus the CDIO approach was developed with input from various stakeholders such as academics, industry, engineers and students. The goal of CDIO approach is to

- Educate students to master a *deeper working knowledge* of the technical fundamentals

- Educate engineers to lead in the *creation and operation* of new products and system
- Educate future researchers to understand the importance and *strategic value* of their work.

The CDIO approach provides a numbers of resources that individual programs can adapt and implement to meet these goals. The two key elements of CDIO approach are: CDIO standards and CDIO Syllabus. The CDIO standards describe 12 principles to effective education and practice. The basic principle is that the authentic context of engineering education is the conceiving-designing-implementing-operating of products, processes and systems. Knowledge and skills are learned in a cultural surrounding and environment that contributes to understanding [7]. The CDIO Standards define the distinguishing features of a CDIO program. They guide and support educational program reform and evaluation, and provide a framework for continuous improvement. The standards aim at improved learning results, students learning more and students having a better experience at their HEIs. The 12 CDIO Standards address program philosophy (Standard 1), curriculum development (Standards 2, 3 and 4), design-implement experiences and workspaces (Standards 5 and 6), methods of teaching and learning (Standards 7 and 8), faculty development (Standards 9 and 10), and assessment and evaluation (Standards 11 and 12) [8]. Each standard is documented with a description explaining the meaning of the standard, with a rationale highlighting the reasons for setting the standard, and with evidence providing examples of documentation and events that demonstrate compliance with the standard.

The another key element and effective practice of CDIO approach – the CDIO syllabus – answers to the challenge that a program should have set “Specific, detailed learning outcomes for personal and interpersonal skills, and product, process, and system building skills, as well as disciplinary knowledge, consistent with program goals and validated by program stakeholders.” The general objective of the CDIO Syllabus is to describe a set of knowledge, skills and attitudes desired in a future generation of young engineers. It offers rational, complete, universal and generalizable goals for undergraduate engineering education. The syllabus organizes learning outcomes in four high-level categories:

- technical knowledge and reasoning,
- personal and professional skills and attributes,
- interpersonal skills: teamwork and communication
- conceiving, designing, implementing and operating systems in the enterprise, societal and environmental context.

These categories comprise well with UNESCO’s four pillars of learning [9]. Actually, the CDIO syllabus can be described as an adaptation of the UNESCO framework to the context of engineering education.

The CDIO syllabus is evaluated and reflected regularly and latest additions to the syllabus has been those dealing with engineering leadership and entrepreneurship. Both of them have been addressed in the syllabus, but lately these important roles of engineers needed to be addressed more adequately. Therefore an extension of the CDIO Syllabus for Leadership and Entrepreneurship has been added providing competence areas such as innovation, managing a project, business plan development and the innovation systems.

To combine CDIO standards and CDIO syllabus meaningfully CDIO community uses term constructive alignment which was introduced by Biggs [10]. Constructive alignment puts together the intended learning outcomes, teaching and learning activities, and assessment of student learning. The program’s intended learning outcomes described in the curriculum and created with the support of CDIO syllabus must be aligned with the teaching and learning activities and assessment guided with the CDIO standards. Thus the CDIO syllabus provides the general goals and CDIO standards provide the tools to success in education.

Although CDIO is not a quality assurance tool the CDIO approach supports it too. Standard 12 guides programs to identify areas of education that should be further developed. This self-evaluation tool supports comprehensive development of education for the purposes of continuous improvement [11].

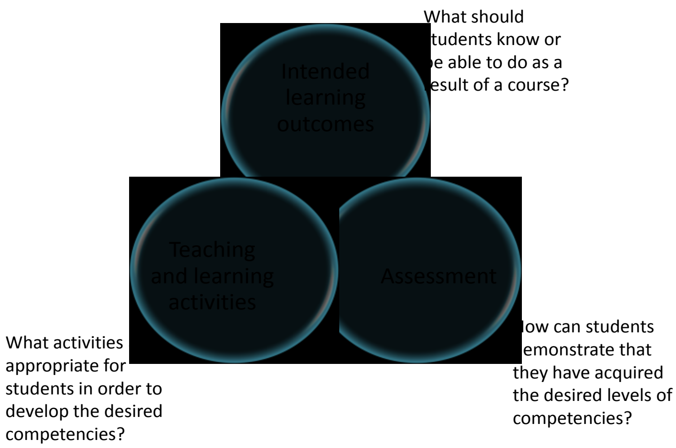

Figure 2. Constructive alignment.

Finally, the fundamental principle of CDIO is that it is adaptable to all engineering schools. Actually, the basic ideas of CDIO approach could offer a starting point for a definition of a new approach in other fields of education too presuming that the most engineering specific parts are adapted to the field in question. Anyway, most of the CDIO standards are quite adaptable in any fields of education as such.

4. Methodology and results

Turku University of Applied Sciences (TUAS) was reconstructed in 2004 so that multidisciplinary faculties assumed the leading role. The aim of the new structure was to facilitate cooperation between different disciplines. The new faculties provided natural working environments with several possibilities to grossing borders and this way supporting innovative initials among students and faculty members equally.

When examining the results of the multidisciplinary organizational structure it can be seen that the volume of research, developments and innovations has increased. The empirical evidence from TUAS supports that creation of knowledge- intensive, multidisciplinary organizations in the universities boosts innovation activities. Knowledge sharing prevents the formulation of closed knowledge pools and especially supports innovation creation. [12]

The empirical evidence of applying innovation pedagogy and CDIO approach is collected during the last ten years at TUAS, and especially at its two largest faculties, Faculty of Technology, Environment and Business (TEB) and Telecommunication and E-business, both being multidisciplinary, having engineering education as their biggest field of study [13]. In working life the way of working includes that problems are solved and innovations are created in groups and networks. R&D projects carried out together with external actors and undertakings funded from external sources are nowadays a part of everyday functions at both of these faculties; i.e. pedagogical methods include clearly more project and collaborative learning. An increasing amount of work conducted in the projects is performed by the students of the faculties. Thus the ability for independent and responsible working methods as well as the mastery of the basics of project work is expected of the students throughout their studies [14].

It seems obvious that the CDIO approach and Innovation pedagogy share similar goals. Both share the ideology about defining the key competences needed in working life and both intend to activate the student and define the learning goals deriving from the needs of the surrounding environment. The CDIO approach has a clear focus on engineering education whereas innovation pedagogy tries to bear in mind the broader needs of the entire economy and focuses on producing valid competencies for the future society where special emphasis is put on innovation creation. Innovation pedagogy can be applied to all the disciplines and to all education be it in the university at any program but also to other levels of education e.g. to secondary education where the basis for the students' understanding of learning is created.

The CDIO syllabus goes to a deep level of detail while defining the necessary competences, but it is good to remember that CDIO syllabus is also a reference list and all of the features are not meant to be followed in detail. Innovation pedagogy focuses on providing the methods and tools to provide the three categories of innovation competencies: individual, interpersonal and networking innovation competences. Innovation pedagogy states that certain cornerstones or "meta-innovations" are needed to succeed in this task. In all, innovation pedagogy can form an extensive pedagogical strategy for any educational institution providing both objectives and methods and tools in order to reach the desired learning outcomes leading to innovation creation.

Part of the innovation pedagogy cornerstones are easily found in CDIO too. For example innovative learning and teaching methods corresponds well with the CDIO standards 7 (Integrated learning experiences) and 8 (Active learning). Cross-disciplinary learning environments and integrated and extensive research and development activities are not specifically emphasized in CDIO, but for example working in different types of teams and cross-disciplinary teams are listed in CDIO syllabus. These competences can be achieved for example with a cross-disciplinary implementation of standard 5 (Design-Build Experiences). When entrepreneurship is understood to include behaviours and skills that allow individuals and groups to engage themselves in creating innovations and coping with high levels of uncertainty in all aspects of their life it seems obvious that innovation competencies include many of the competencies needed when becoming an entrepreneur. [15]

Entrepreneurship and internationalization are included in the CDIO syllabus in various parts. Internationalization is mentioned as communication skills in foreign languages, developing a global perspective and working in international organizations. Entrepreneurship is named in enterprise and business context as well as in the new syllabus addition engineering entrepreneurship.

5. Conclusions – towards engineering education providing innovation competences

In this paper it has been discussed how learning and teaching are understood according to innovation pedagogy and how the CDIO approach is interconnected with innovation pedagogy. It has been stated that they both face very similar challenges and share parallel goals and objectives. Our conclusion is that the CDIO approach can be strengthened by innovation pedagogy and its objective to provide the students with innovation competences in order enable them to participate in the innovation processes in their future working places and develop them. We believe that innovative solutions are created through social learning (~collaborative learning) in diverse surroundings and emphasize the significance of boundary crossing in higher education and its ability to provide the different types of knowledge needed in innovation creation. The findings and the value of this paper extends the concept of knowledge in learning context to support the development of innovation competences by integrating the CDIO approach with innovation pedagogical approach.

For even larger scale reform in the engineering education, we should be able to reliably proof the power of these new educational methods. Because of the lack of existing relevant tools for that purposes, TUAS is now developing the Innovation Competencies Barometer (ICB). TUAS is at the moment coordinating international and national operations related to the development of ICB and according to the project plans we should have tested and validated the tool before the end of 2013. The final goal of this work is:

- To design and validate a measuring tool: The Innovation Competencies Barometer (ICB)
- To produce research-based knowledge on the achievement of innovation competencies generated by new experimental R&D based learning methods

By using the ICB and testing the results of different teaching and learning methods universities get up to date information about the usefulness of these methods and can make decisions on how to implement them to wider use. Teaching staff has to be educated to use methods which enhance the achievement of innovation competencies. The information can also be used for informing and motivating students to participate in these study units carried out in a different way compared to the old more purely lecture based ones. Ultimately it is the working life, companies and other organizations that benefit from the newly educated professionals who will possess better qualifications and who will be better prepared to act in the diverse innovation processes in the working life. The ICB enables also to involve experts outside higher education organizations more actively to the pedagogical development processes of engineering education. [16, 17]

To sum up, on a practical level innovation pedagogy integrated with CDIO approach means applying existing learning and teaching methods in a creative, value-increasing way. Simultaneously, new methods are developed and put into practice while ensuring that students take responsibility for their learning and that they actively pursue their learning objectives. As a result, graduating students have professional skills and qualifications that are both innovative and development-oriented. Innovation pedagogy strengthened with CDIO approach moves further from traditional theoretical learning to the application of learned skills to practical development challenges.

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Presenter: This paper is presented by Taru Penttilä

Early Indicators for Student Success in an Undergraduate Electrical Engineering Programme

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Abstract

In this paper a preliminary study is presented which identifies whether selected courses within the first 1.5 years of a specific electrical engineering undergraduate degree programme can be used to predict successful student performance. The study focuses on course results for students entering the programme between 2007 and 2010. Student performance is catergorised into four success levels that are measured by the number of years to completion of the programme. Engineering courses from the first year of the programme, and the first semester of the second year of the programme are included in the study. It is found that students completing the programme in the minimum number of years to completion (4 years) have mark distributions with a high mean (average) and a small standard deviation in all courses selected for the study. The majority of students failing to complete in the minimum number of years have a significantly poorer performance in second year courses in the first semester in comparison to first year courses. This indicates that first year courses should not be used in isolation when trying to determine the possibility of success in the performance of a student.

Keywords: *undergraduate, cohort, analysis*

1. Introduction

A preliminary study is presented in this paper that analyses student success in completing a four-year undergraduate Bachelor of Science degree in Engineering in the branch of Electrical Engineering. The aim of the paper is to produce indicative trends to assist in predicting the success of a student from an early stage in the programme. The dataset chosen includes student enrolment in first year between 2007 and 2010. For the purposes of this study, the criterion for student success is measured by the number of years taken to complete the degree programme. Student performance in selected courses from early years of the programme is presented in relation to the number of years taken to completion. The paper is structured as follows:

- Overview of the four-year electrical engineering programme.
- Factors related to student intake into the programme.
- First and second year courses chosen from the first 1.5 years of the curriculum to assess student performance.
- Methodology and limitations in finalising the dataset.
- Resulting trends and statistics.

2. The Electrical Engineering Degree Programme

The electrical engineering degree programme discussed in this paper is a fixed four-year undergraduate programme at the University of the Witwatersrand, Johannesburg in South Africa. The programme is accredited by the Engineering Council of South Africa (ECSA) under the Washington Accord of the International Engineering Alliance [1]. Students are expected to complete the degree programme within the minimum number of 4 years. If a student fails a course in the fixed curriculum, the student will be required to repeat the failed course, which will extend the number of years to complete the degree. The average number of years to completion of the degree programme is between 5 and 6 years.

The degree programme is structured such that students may only proceed to higher years once all course prerequisite conditions have been met. If a student fails a course, he or she will have an opportunity to write a supplementary exam. However, supplementary exams are granted to students based on certain criteria: first year students are only granted a supplementary if only one course is failed and the course mark is above 40%, second to fourth year students are only granted supplementary exams if no more than two courses are failed and the average of the failed courses is above 40%.

2.1. Overview of Courses in the Programme

A summary of the courses offered as part of the fixed-curriculum by each year of the degree programme is as follows:

1) First Year: Fundamental courses in the first year include Mathematics I, Physics I, Mechanics, Chemistry I, Electric Circuits, Engineering Skills & Design (consisting of two components: Engineering Design and Critical Thinking through English literature).

2) Second Year: Students continue with courses in Mathematics II, and Physics II, and are required to apply fundamental knowledge in courses related to Electronics I, Software Development I, Signals & Systems I, Microprocessors, Electric & Magnetic Systems, Data Structures & Algorithms and Vacation Work I.

3) Third Year: Students have a choice to continue with traditional electrical engineering (EE) or branch into information engineering (IE). Core courses include Electrical Engineering Design I, Electronics II, Software Development II, Signals & Systems II, Control I, Economics of Design, Probabalistic System Analysis and Vacation Work II. The EE elective stream includes additional courses in Mathematical Methods, Power Engineering I and Electromagnetic Engineering. The IE elective stream includes additional courses in Computational Mathematics, Data and Information Management and Communication Fundamentals.

4) Fourth Year: In the final year, students are required to take core courses and 3 additional elective courses depending on the EE or IE stream. Core courses include Measurement Systems, Systems Management & Integration, Engineer in Society, Electrical Engineering Design II (a six-week design project), and Electrical Engineering Laboratory (a six-week practical project). Additional elective courses include Software Engineering, Software Development III, Control II, Electromagnetic Conversion, High Voltage Engineering, Power Transmission & Protection, Power Engineering II, High Frequency Techniques, and Network Fundamentals.

2.2. Students Entering the Programme

Students entering the electrical engineering programme come from a wide variety of educational, social and cultural backgrounds [2]. South Africa has eleven official languages, all of which are possible languages of educational instruction in secondary schools across the country [3]. The language of instruction at the University of the Witwatersrand is English.

There are a variety of different types of secondary schools which are state-owned or private and dispersed geographically in either rural or urban areas. Students completing secondary education are subject to write standardised national exams to qualify for a National Senior Certificate (formally known as Matric Exams) for at least six secondary school subjects. The results of these exams are a determinant for entrance requirements to local universities. Performance in relevant National Senior Certificate subjects determines the acceptance for certain degree programme.

3. Early Indicative Courses Selected for the Study

Electrical engineering-related first year and selected second year courses are selected for this study to provide early indicators for student success in this programme. These courses assess the capabilities of the students to apply fundamental concepts to a problem within a limited scope; and analyse and effectively communicate the results. The first year courses chosen are the Engineering Design, Critical Thinking and Electric Circuits courses. The selected second year courses are electrical engineering courses taken in the first semester; these courses include Software Development I and Electronics I. These chosen courses take place in the first 1.5 years of the electrical engineering curriculum programme, and mean to serve as indicative courses to identify a student's ability to succeed in the programme.

3.1. First Year: Engineering Design

Engineering Design is a component of a first year course called Engineering Skills & Design. This is a full-year course that runs over two semesters in first year. This first component is project oriented; introducing students to fundamental design concepts and effective technical communication. This component is largely assessed on technical reports. There are three major assessments: a research report, an investigation project and a practical design project that includes a design, building, testing and teamwork components.

This course is assessed on the following criteria:

- Technical communication,
- Engineering creativity and imagination,
- Technical content and
- Professional, ethical, social, economic and environmental issues.

Additional assessments include oral presentations, technical drawings, mathematical simulation using a computational language and testing of built models.

3.2. First Year: Critical Thinking

Critical Thinking is a humanities-based component of the first year course called Engineering Skills & Design. This is a full-year course that runs over two semesters in first year. This second component is essay-oriented; enforcing the ability to reason, construct an argument and ensuring that students engage critically with written texts such as classic novels and imaginative concepts such as science fiction.

This course is assessed on the following criteria:

- Language skills,
- Reading and comprehension,
- Critical analysis and argument development and,
- Creative thinking.

3.3. First Year: Electric Circuits

Electric circuits is a full-year course in the first year of the programme that runs over two semesters. This course introduces fundamental methods for analysing and understanding circuit theory. The assessment components in the course include tests, an exam and practical laboratory assignments.

3.4. Second Year: Software Development I

Software Development I is a first semester course in the second year of the programme. This course introduces methodical and logical abstraction of concepts and ideas through programming techniques. The assessment components in the course include a written test, practical programming test, project and exam.

3.5. Second Year: Electronics I

Electronics I is a first semester course in the second year of the programme. This course builds on and extends knowledge from the first year Electric Circuits course discussed in Section 3.3. Students are exposed to analogue and digital circuit concepts and components. This includes an understanding of modular circuits and the interfacing between circuits. The assessment components in the course include a test, laboratory exercises, project and exam.

4. Methodology

Students enrolled in the electrical engineering degree programme between the years of 2007 and 2010 are included in this study. Only students who have graduated are included in the dataset. However, students currently in their final year in 2013 are assumed to graduate in 2013 as results have not been finalised for this study, and are therefore included in this dataset. Student success is catergorised by the number of years taken to completion of the degree programme, as shown in Table 1. A total of 154 student records make up the dataset distributed by success levels; Level 1: 60 students, Level 2: 51 students, Level 3: 26 students and Level 4: 16 students.

The success levels are defined as follows:

- Level 1: Completion in 4 years.
- Level 2: Completion in 5 years.
- Level 3: Completion in 6 years.
- Level 4: Completion in 7+ years.

Table 1: Dataset of student progress according to year of enrolment.

Year Enrolled	Year of Completion			
	2010	**2011**	**2012**	**2013**†
2007	4 years (19 students)	5 years (11 students)	6 years (11 students)	7 years (16 students)
2008		4 years (12 students)	5 years (15 students)	6 years (15 students)
2009			4 years (12 students)	5 years (25 students)
2010				4 years (17 students)

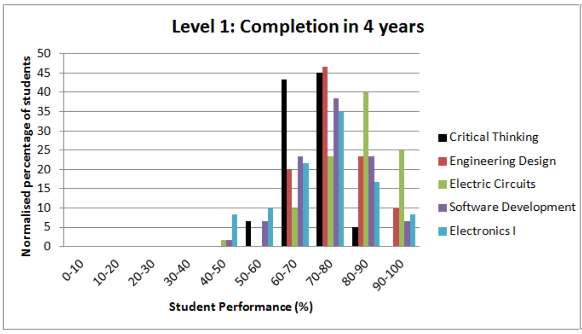
† Students currently in final year in 2013 are assumed to have completed the degree programme in this study. A small percentage of students do not complete the final year, so this is a valid assumption.

Students that are classified as being in Level 1 are considered in the highest level of success, since the minimum
number of years to completion in the fixed curriculum is 4 years. Students classified in Levels 2 and 3 fit into the general average, as the estimated number of years to completion is approximately 5-6 years. Students classified in Level 4 have been in the programme for longer than expected. Although student success can be characterised by the number of years to completion, personal circumstances that individual students face while they are in the programme are not explicitly included in this study. Therefore, students appearing in Levels 2-4 are not considered less qualified or less capable than students appearing in Level 1.

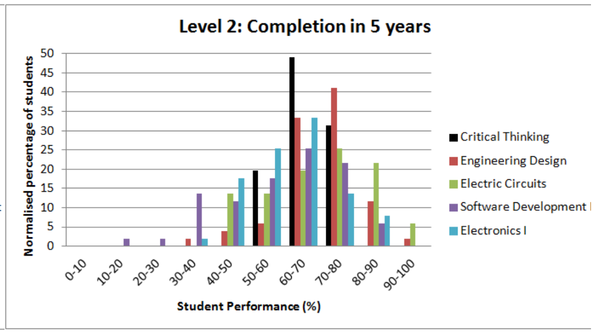
Datasets are categorised by success levels in individual courses and normalised to a percentage of the total number of students included in each level. All marks are represented as percentages. A percentage of 50% and higher is regarded as a passing percentage. Marks presented in this dataset are recorded before supplementary exams are granted. Marks for each course are recorded as first attempt by a student at the course. No repeat marks for a course are included in this dataset.

5. Data Analysis

Figure 1 (a-d) show histograms representing performance trends for assessed courses for Levels 1-4. All trends are represented as percentages in the individual datasets for each success level.



(a)



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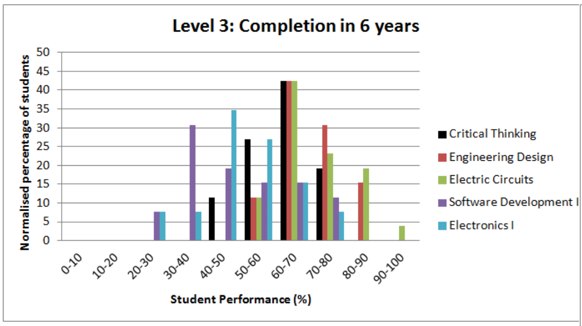

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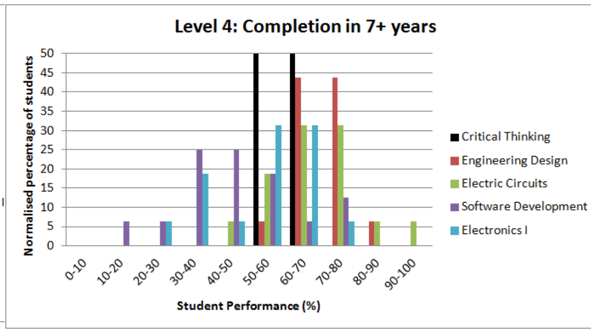


(d)

Figure 1: Assessment of student performance in early courses of a four-year electrical engineering degree programme. (a) Students completing in 4 years *(60 students)*. (b) Students completing in 5 years *(51 students)*. (c) Students completing in 6 years *(26 students)*. (d) Students completing in 7+ years *(16 students)*.

1) Level 1: Performance trends for students completing in 4 years are presented in Figure 1 (a). The marks in all subjects generally appear in the higher percentage ranges. Although a student may have a failing mark for some of the courses, the mark appears in the 40-50% range, which is in the allowable range for a supplementary exam. In this group, students have passed supplementary exams in early years of the programme, adapted to the demands of the programme and completed the degree in 4 years.

2) Level 2: Performance trends for students completing in 5 years are presented in Figure 1 (b). Peaks in first year engineering components appear in the 70-80% range, and peaks in the second year courses appear in the 60-70% range. Students appearing in this dataset are showing signs of weakness in the Software development I course. The majority of these students complete first and second year, and then repeat a course in a later year of the programme.

3) Level 3: Performance trends for students completing in 6 years are presented in Figure 1 (c). From this set of data, it is shown that first year engineering components (Engineering Design and Electric Circuits) have distributions above the 50% mark, but second year performance is generally weak – the Software Development I distribution peaks in the 30-40% range and Electronics I distribution peaks in the 40-50% range. This group also indicates weak performance in Critical Thinking, which implies that some students in this group might not be fully proficient in English.

4) Level 4: Performance trends for students completing in 7+ years are presented in Figure 1 (d). These trends are generally more inconsistent due to a smaller sample size of 16 students. From first year course trends, it can be seen that these students are generally capable in the fundamental engineering first-year courses and are competent in English with 50% of the dataset appearing in the 50-60% range, and 50% appearing in the 60-70% range. Student performance in Software development I peaks in the 30-50% range. However, Electronics I performance peaks is stronger with peaks in the range of 50-70% with a minor peak in the 30-40% range.

5.1. Statistical Analysis

The mean and the standard deviation are determined for each course in each level of success. The trends for the mean and standard deviation for each level of success are provided in Figure 2. Table 2 presents the mean for each category and Table 3 presents the standard deviation.

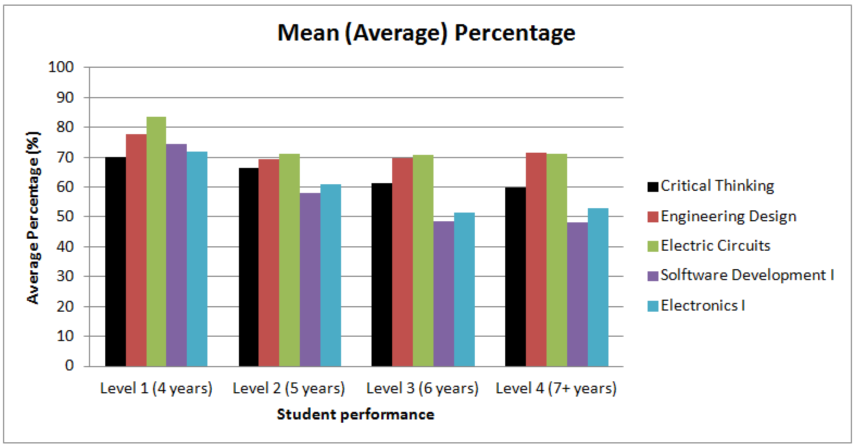
Table 2: Mean (average) mark for student performance in each course.

Course	Mean (Average) Performance (%)			
	4 years	5 years	6 years	7+ years
Critical Thinking	70.05	66.23	61.27	59.88
Engineering Design	77.54	69.34	69.83	71.38
Electric Circuits	83.45	71.06	70.88	71.06
Software Development I	74.54	57.98	48.60	48.16
Electronics I	71.81	61.07	51.40	53.00

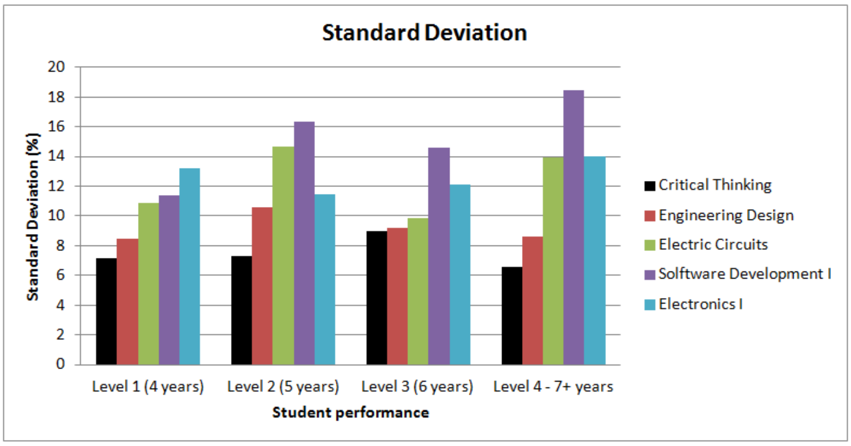
Table 3: Standard deviation of trends from marks for student performance in each course.

Course	Mean (Average) Performance (%)			
	4 years	5 years	6 years	7+ years
Critical Thinking	70.05	66.23	61.27	59.88
Engineering Design	77.54	69.34	69.83	71.38
Electric Circuits	83.45	71.06	70.88	71.06
Software Development I	74.54	57.98	48.60	48.16
Electronics I	71.81	61.07	51.40	53.00

The mean for each trend is presented in Figure 2 (a) and Table 2. In general, these trends show that first year engineering components (Engineering design and Electric circuits) have a higher mean in all success levels. The mean performance in second year courses is found to be lower than first year engineering components. From higher success levels (Level 1) to lower success levels (Level 4), it is found that this gap between the first year engineering component performance and second year course performance becomes greater. This indicates that engineering-specific courses in the first year of the programme cannot provide clear success indicators, and that weaker students struggle as the courses become more specialised, such as second year courses.



(a)



(b)

Figure 2: Statistical analysis for each success level, from Levels 1-4 in courses. (a) Mean (average). (b) Standard deviation.

The standard deviation for each trend is presented in Figure 2 (b) and Table 3. Software Development I shows the highest deviation from the expected mean value in Levels 2-4. This follows the trend that the standard deviation in all courses varies the most in Levels 2 and 4.

The overall performance in the Critical Thinking component is characterised by a small range on the mean, roughly between 60-70% and little variance in the standard deviation. This component cannot clearly provide an indication to student success in the degree programme.

1) Level 1 (4 years to completion): These trends indicate that students completing the degree in 4 years have a higher and more consistent mean across all courses than in other success levels. Second year marks indicated in Software Development I and Electronics I maintains a relatively high mean above 70%. There is a smaller standard deviation for marks in this level, which suggests a consistency of the performance of students in this category.

2) Level 2 (5 years to completion): The performance mean for students completing in 5 years is relatively high and has values between Levels 1 and 3, as expected. Second year marks indicated in Software Development I and Electronics I indicate an average mean performance around 60%. However, the standard deviation on the mark distributions in this success level is large - in particular, with Electric Circuits and Software Development I.

3) Level 3 (6 years to completion): The mean trends for students completing in 6-7+ years (Levels 3 and 4) are similar across all courses appearing in the study. Second year marks indicated in Software Development I and Electronics I indicate marginal mean performance around 50%, which indicates that students generally have a limited understanding of the second year topics. It is difficult to differentiate students from Level 3 and 4 in terms of performance in early years of the programme. However, the standard deviation in the performance in students completing in 6 years is relatively low, especially in first year components, which may indicate a better fundamental grounding from first year topics. It should be noted that the smaller dataset of 26 students makes it difficult to assert conclusions on trends in this category, but provides some insight.

4) Level 4 (7+ years to completion): The mean performance in Level 4 is similar to performance in Level 3, where second year topics have a marginal mean performance around 50%. In addition to the low second year performance, the variance in this category is very unpredictable. This category has a particularly high standard deviation in Software Development I. The smaller dataset of 16 students makes it difficult to assert conclusions on trends in this category, but provides some insight.

6. Discussion

In this paper a preliminary study is presented to determine whether student performance can be evaluated in selected courses of the first 1.5 years of an electrical engineering degree programme. The purpose of this study is to use the results in these early courses to serve as tools in predicting the performance of a student in the programme and identify which students may finish within the minimum number of years and which students may struggle to complete the programme.

The study suggests that students with successful Level 1 performance (completion in 4 years) in the programme are characterised by a high mean (average) and a low standard deviation in both first and second year courses. This indicates that the general performance is of high standard, and there are few outliers. A small percentage of successful students in the Level 1 category fail early courses and this failure is often borderline and corrected by passing supplementary examinations.

This study indicates that all students completing the programme (Levels 1-4) have high first year results and are not likely to fail any first year engineering courses. Weak performance is identified more clearly in the first semester second year courses. If there is a large difference between first year marks and second year marks, it is shown that there is a good possibility that these students may have difficulty completing the programme close to the minimum number of years. This pattern is clear amongst students classified in Level 4 who have significantly weaker performance in the first semester second year courses despite obtaining average to high marks in first year courses. This may be an indication that students completing first year are not fully prepared for more challenging applied engineering concepts introduced in second year courses.

This preliminary study has only taken into consideration the first 1.5 years of electrical engineering courses in the programme. This study has shown that the courses taken into consideration can assist in early identification of strong and weak student performance. It is expected that the inclusion of all courses in the first 1.5 years (including Mathematics, Physics and Chemistry) would provide a more coherent picture. From an institutional perspective, further steps can be considered in identifying how secondary school education impacts performance of a student in the programme.

7. Conclusion

The performance of a student in the electrical engineering degree programme can be characterised by selected early courses within the first 1.5 years of the programme. It is found that students completing in a fewer number of years have higher marks in early courses, and there is a smaller difference between first year and second year marks. If there is a large difference between first and second year marks, it may be an indication that the higher years of the degree programme will be more challenging. Therefore, if students successfully pass first year with high results, it should not be assumed that this success would be reflected in the rest of the programme. This paper provides a framework and platform for further studies and analysis on the electrical engineering programme at the University of the Witwatersrand.

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Enhancing Engineering Education by Including Non Traditional Items in Curriculum Design: Practical Means and Methods Towards a Best Practice Approach

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Abstract

As globalization and competitive pressure steadily increase, there is a growing demand for highly qualified engineers. The demand focuses on engineers who do not just have excellent competences in their field of specialization but also a general understanding in the non-technical field. This includes topics such as economics, costing, business administration, fundamentals in law, sales, project-, process- and quality management as well as relevant social and soft skills.

Several surveys revealed that there is a clear gap between the competences that industry requires and the actual skills of the graduate. Moreover, many interviews have been conducted with industry leaders to find out means to increase the fit between the requirements of the position/ the organization, on one side and the engineer's skills, on the other side.

Based on these findings a set of modules with "non- traditional items" was included in the technical Bachelor Programs at MCI. Each module addresses important learning outcomes related to, namely: General Management Skills/ Social and Soft Skills/ Integrative Skills/ Reflective Skills.

Keywords: *General Management Skills/ Social and Soft Skills/Integrative Skills/ Reflective Skills*

1. INTRODUCTION

The paper raises the question how engineers can be educated and trained sufficiently in order to meet 21st century's needs – with its complexity, its vast technological development and its various societal requirements.

The aim of this paper is to present practical means and methods on how engineering education can be enhanced by incorporating a relevant set of non-traditional items in curriculum design. This includes general competences in the area of key skills, business administration, management and leadership.

The following comments are directly quoted from a key-note speech held by the former president of the WFEO (World Foundation of Engineering Organisations) K. Ayadi at the 2007 iNEER conference in Coimbra, Portugal:

- "We need engineers with great minds, and great ideas, able to act as leaders not simply followers and executors of work directed by others."
- "Do engineers have the potential to be leaders? Are they trained to be leaders? This ability is a derivation of interpersonal communication, problem-solving and conflict management skills."
- "We have to admit that only a few engineers have succeeded in becoming leaders in their respective working areas: Engineers tend to focus on 'details' and not on the big picture."
- "Changing engineers' attitudes and behaviors require the change of education paradigm: Education in many countries remains to some extent dominated by an information based curriculum and a teaching

style which doesn't favor questioning, exploration and autonomous learning. Success in today's knowledge-based economy requires that graduates are educated on the basis of critical thinking and problem solving approach -> Rethink engineering education."

- "Several studies carried out in many countries have proven that there still exists a gap between the range of skills that graduates are equipped with and the skills and qualifications that are sought after by employers."

Moreover the students/ graduates have to learn where they can perform best according to their individual skill set, personality and values. The legendary management expert Peter F. Drucker clearly stated: *We will have to learn where we belong, what our strengths are, what we have to learn so that we get the full benefit from it, where our defects are, what we are not good at, what our values are. For the first time in human history, we will have to learn to take responsibility for managing ourselves. And as I said, this is probably a much bigger change than any technology—a change in the human condition. Nobody teaches it—no school, no college—and probably will be another hundred years before they teach it. - People will have to learn to manage themselves, to build on their strengths, to build on their values* [1].

While hard technical skills are important, there has been increasing demand from industry in recent years for their employees to have broader skills [2]. The authors, Hasbullah and Sulaiman [3], cited a survey conducted more than 15 years ago which stated that more than two thirds of 1400 interviewed CIOs rated soft skills as very important. A similar emphasis is placed by various authors stressing the importance of major revisions in engineering curricula [4] by reacting to the lack of soft skills which are basic for a professional.

Moreover, accreditation agencies reflect the industry's requirements by strongly considering soft skills in their guidelines. For example, the Accreditation Board for Engineering and Technology (ABET), as the sole agency responsible for accreditation of educational programs in engineering in the United States, is reaffirming a set of "hard" engineering skills but is also introducing a set of "professional" skills as equally important including communicative or teamwork skills [5]. A comparable development is to be seen in German-speaking countries. ASIIN [6], the German equivalent for the American accreditation board, also highlights the importance of a holistic education by integrating technical, business and social aspects in engineering curricula [7].

The following figure also shows the disparity between knowledge taught at universities and know-how required at the workplace [8]

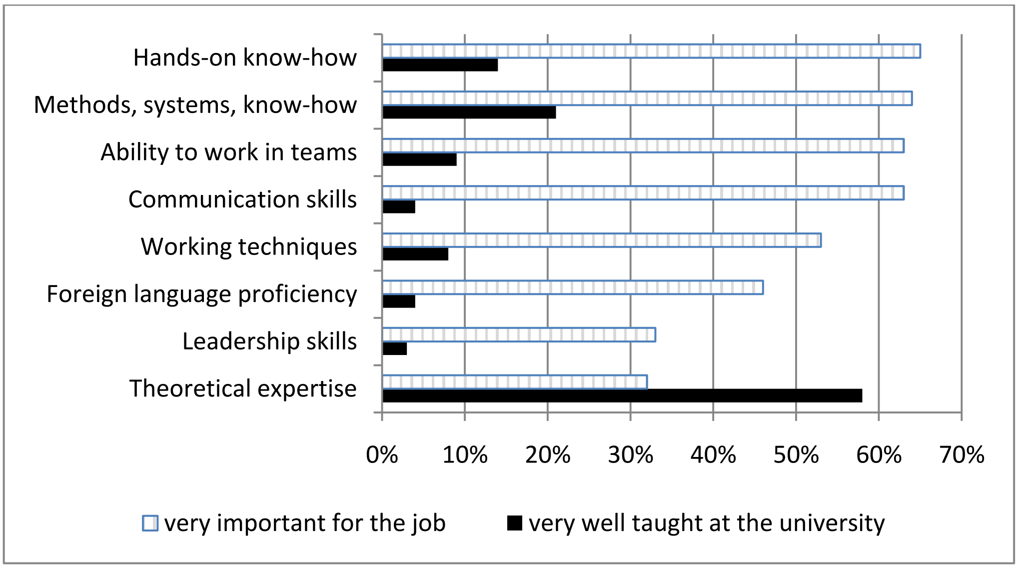

Figure 1: Disparity between knowledge taught at universities and know-how-required at the workplace [8]

2. THE MCI EDUCATIONAL APPROACH

In order to close the gap outlined in section 1 Management Center Innsbruck (MCI) developed an integrated education program in the area of soft skills [9]. This program is successfully implemented now. A text book containing the major aspects of the program was published in 2008 [10]. As a second step, several courses related to the development of management and leadership skills were also introduced in the Bachelor's and Master's curriculum [11]. Salient features of the institution (MCI) are highlighted in the following subsection.

In 1994, the “Universities of Applied Sciences (UAS)” in Austria were integrated into the structures of the Higher Education (HE) Systems in the German-speaking countries [12]. A UAS degree program is “equivalent to but different from” a traditional university degree program and is characterized in particular by its close relations with trade and industry, its practical orientation and customer focus, a strictly organized program schedule and a highly service-oriented approach. Being organized on a private-law basis the MCI’s UAS degree programs are officially accredited under public law. The degree programs at MCI include, namely:

- Practice-oriented training and education at university level;
- A science-based approach;
- A strictly organized schedule with a limited program duration;
- An optional semester abroad at one of MCI's many partner universities;
- Close relations with trade and industry through lecturers, joint projects and mandatory internships;
- An officially accredited degree conforming to EU HE standards;
- Eligibility to take up doctoral degree programs at Austrian universities.

3. NON TRADITIONAL ITEMS PROGRAM IN TECHNICAL BACHELOR

Based on the experience of the last 5 years the technical programs have been revised. The following set of courses is now incorporated in the bachelors’ programs at the MCI. The tables below highlight the curriculum flow. The numbers in the table indicate the semester credit units (SWS), where 1 credit unit (SWS) is equivalent to 15 teaching units i.e. 45 minutes/unit. The numbers in the last column display the ECTS (European Credit Transfer System, where 1 ECTS is equivalent to a total work load of approximately 25-30 hours).

MCI’s motto: “Bridging University and Business” & “Mentoring the Motivated” emphasize its orientation and are also a strong guidance for all our activities. They are especially reflected in the “Non Traditional Items Program” explained in the following two subsections.

3.1 Part I: Business and Management for Engineers

It can be said that at the MCI a general “entrepreneurial approach” is fostered in the engineering degree programs. Business courses were included right from the inception of its technical programs in 1998[10]. Minor adaptations have been made recently where courses have been shifted and aligned accordingly. Moreover, the course “Introduction to Business and Management for Engineers” was introduced in the second semester in order to give the students a general overview of business fundaments. This course is also an eye opener for the subsequent courses such as process-, project- and quality management, which are particularly important for engineering graduates. In the 4th and in the 5th semester fundamentals in business economics as well as legal aspects are taught. The program ends with a lecture on marketing and sales. This course helps the student to understand the tools of marketing and selling technical products.

Overall the business and management courses amount to 10 of the required 180 ECTS, i.e. 5.6% of the workload in the technical bachelor program. The inclusion of business & management courses in technical disciplines further accentuates MCI philosophy: “Bridging University and Business”

Course/ Semester/SWS[1]	1	2	3	4	5	6	ECTS Credits
Introduction to Business and Management for Engineers.		1					1
Process Management			1				1
Project Management			1				1
Quality Management				1			1
Fundamentals in Law				2			2
Costing/ Business Accounting and Controlling					2		2
Marketing and Sales					2		2

Figure 2: Business and Management Courses in MCI technical Bachelor Programs (Part I)

3.2 Part II: Key Skills Program for Engineers

Like the business and management courses, the social and soft skills (key skills) form an integral part of MCI’s engineering curriculum. Details can be found in [9]. Based on the second slogan of the MCI “Mentoring the motivated” a task force has been founded/created to enhance the key skills trainings to put our philosophy “Mentoring the motivated” into practice. The following mission statement was developed for the key skills program:

We care for holistic competence development with high relevance for the job market, putting much emphasis on the development of the personalities. As mentors, teachers and coaches we offer platforms for knowledge and experimental learning as well as personal growth, so that our graduates are able to maturely design their individual career path with healthy self confidence in a time of increasing complexity and dynamic.

The following set of values serve as a guideline for all our actions in the program:
- Respect
- Individuality
- Appreciation
- Strong orientation towards individual potential
- Transparency
- Autonomy
- Authenticity

We consider the key competencies of MCI s’ technical program as:
- A quality seal for employers
- A threshold for responsible positions
- An important feature in the engineers’ qualifications

⇨ strengthens motivated people in their personality development

The program underlines MCI’s innovative role as an entrepreneurial school.

In order to secure the success of the program the following aspects must be taken into careful consideration:
- Seminars ideally take place outside the formal lecture hall environment –> paradigm shift from traditional learning and accumulation of knowledge towards increased (self) reflection
- Selection of lecturers according to their identification with the overall concept (one voice approach)

[1] “Semester credit units = SWS”, where 1 SWS is equivalent to 15 units i.e.45 minutes/unit

- Periodic talks with our “MCI Advisory Board” (entrepreneurs and specialists of relevant companies that hire MCI engineering graduates)
- Strong focus on the individual: increase reflective capacity and personal leadership
- Continuous development in the framework of a learning community

The following table displays the key competence training program:

Course/ Semester/SWS	1	2	3	4	5	6	ECTS Credits
Potential and Personality	1						1
Team Competence	1						1
Working Skills and Self -Management		1					1
Rhetoric and Presentation			1				1
Communication and Conflict Management				1			1
Management and Leadership					1		1

Figure 3: Key skills courses in MCI technical Bachelor Programs (Part II)

Overall the key competence courses sum up to 6 ECTS, amounts to 6 of 180 ECTS = 3.3% of the workload in the technical bachelor program.

4. Pedagogical Approach/Educational Objective

According to Marsh [13] “The graduate of the future is expected to exhibit a totally different range of skills from their forebears.” This challenge can only be faced by a wide range of measures. The educational objective of the MCI engineering programs is to holistically equip the graduate with crucial competences such as technical, methodical and social competences in order to facilitate a better transfer from university to the business world. It can also be said that at the MCI a general “entrepreneurial approach” is fostered in the engineering degree programs as well as a strong focus on practice [14, 15]. The goal is to confront the student with non-technical skills in such a way that it also has an impact on the other engineering courses and modules. Attendance in all courses is mandatory.

The seminars are taught by different professors, lecturers and business leaders. Currently about 10 external and 10 internal professors/ lecturers are involved in the program. Each of them has a unique didactic and pedagogical approach using various methods such as upfront teaching, personal reflection phases, teamwork, and case studies. The (small group) seminars are usually intensive (2 days) preferably at another location than the traditional classrooms. Assessment methods are designed to meet the particular requirements of each module. These methods vary from 100% examination to 100% continuous assessment. Currently the ratio constitutes 70% examination and 30% continuous assessment. In the key competence program students are required to write reflection papers with special emphasis on the application of the issues discussed in class. The reflection papers written in all 6 courses serve as “learning portfolio” which enables the student to see the links between the courses. This learning portfolio also contributes to the internship that each student has to complete successfully in the 6th semester.

Discussions among professors of the engineering program have indicated that the parallel approach of management/key competence training alongside other engineering courses is a mean to increase the effectiveness of the technical courses, where those skills are also needed. It must be clearly stated that the program is not an add-on to the engineering curriculum but an integral part of it. This kind of an active teaching and learning co-operation is part of the general pedagogical approach at MCI [16].The parallel approach of management/key competence training alongside other engineering courses have increased the effectiveness of the technical courses, where those skills are also needed.

5. Degree of Novelty

It is true that the development of generic, non-technical skills have been embedded in many engineering programs for years [17]. A simple internet search shows that particularly in the English-speaking world many universities offer additional (optional) courses in engineering programs in order to address business issues for the engineering community. Even in the German-speaking world many academic institutions offer some training in the field of business administration and management. An insight into the key skills course programs offered in engineering curricula of other German universities showed that there is a rather diverse collection of independent modules and courses.

The unique aspect of the MCI program is the fact that three MCI lecturers with different backgrounds have worked together in order to develop a concise educational program in this field, which now forms an integral part of the technical programs at MCI. The development of these courses by a diverse team has also helped to reduce redundancy. The literature review showed that at least in the German-speaking world, there is not yet a single textbook available that offers such a broad variety of aspects specifically catered to the engineering community. Therefore, the program equips the engineering student/graduate with basic expertise in general management and key skills that make up less than 10% of the workload in the total bachelor study program.

The program has a strong link to MCI‘s mission which is also displayed in the two slogans: “Mentoring the Motivated and “Bridging University and Business”. We believe that becoming a professional is a lifelong process which additionally requires reflective competence in order to identify and develop one’s individual potential. Thus, fostering reflective competence occupies an indispensable part of engineering education. The students become more aware of their individual talents leading to increased employability. Therefore, the program facilitates students to understand and benefit better from their talents, strengths and values. It is therefore, a valuable contribution for early career orientation and better placement.

6. Outcome, Conclusion, next Steps

The education program is still in the implementation phase at MCI. Several goals have been achieved so far:

- A core team of two full-time professors and several external lecturers from different backgrounds have developed and further improved the program concept taking into account the industry’s requirements.
  Furthermore, the engineering students highly support and readily accept these modules in their engineering program.
- Managers and leaders of relevant companies appreciate this concept and acknowledge the holistic approach of the engineering program at MCI. They value the contribution of this concept as an important part of the engineering education. Student evaluations of about 68 seminars (around 800 evaluation forms) showed excellent results. The average evaluation grade was 1.44 on a scale from 1 = very good – 5 = fail [19].
- In an internal MCI survey among 127 technical graduates who had been working in companies for three to five years, technical knowledge, problem-solving competence, executive power and teamwork were identified as the most important competences for vocational success. Asked for the reasons why they have decided to study engineering, at first technical expertise and career advancement were the main reasons mentioned, whereas social competence was ranked last. However, after three to five years of work experience, the graduates realized the positive impact of social competences on their success and in hindsight, appreciated the key competence subjects that complement the technical contents [22].

Given that engineering education has evolved since its origins [18, 20, 21] and that it finds its strengths in being resilient and flexible, the authors express their confidence that this approach is a valuable contribution for future engineering education. The main thrust is, thus, on equipping young engineers well for the globalized and fast-moving world of the 21st century.

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Presenter: The paper is presented Gerhard Hillmer

Students' Experiences of R&D project-based learning – Case ICT ShowRoom

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Abstract

Working life is changing and there is an increasing need for innovation-based, applied knowledge. New ways of thinking and operating in complex and changing situations require new ways of learning. Above all, learning should generate new information across multi-disciplinary boundaries where learning is understood as a co-creative and social interaction-based activity. Learning through R&D projects serves this aim well. In this paper, we present a study on students' experiences of a project-based learning concept called ICT ShowRoom, an annual student project exhibition and competition organized by three different universities in Turku, Finland. The study was implemented by conducting eight group interviews and a participant survey questionnaire during the exhibition event. The analysis of the gathered information shows that the students were very enthusiastic about this way of learning. One of the main motivators was an opportunity to work together with well-known ICT companies. For some teams, free hands were given to develop their own innovations, which they also found inspiring.

Keywords: *Learning by Doing, Learning and Teaching Methods, ICT & Engineering Education, Innovation Pedagogy*

1. Introduction

The education system must be able to meet the changing needs of working life. New ways of learning must be developed because there is an increasing need for innovation-based, applied knowledge. For teaching to students new ways of thinking and operating in complex and changing situations, the Turku University of Applied Sciences (TUAS) is applying an innovative pedagogical learning approach. Learning should not only be knowledge acquisition and repetition. Above all, it should generate new information across multi-disciplinary boundaries where learning is understood as a co-creative and social interaction-based activity. Learning through research and development (R&D) projects serves this aim well. Students develop their project skills but also their social skills and ICT knowledge.

At TUAS, innovation pedagogy has a notable role in the institution's strategic policy. Innovation pedagogy aims to provide students with professional skills that enable them to participate in the innovation processes of their future organisations. It has been discovered that the development of inventions and patents offers an interesting learning environment in itself. Although inventions and innovations are often developed for solving technical problems or challenges, a growing share of new innovations deals with the development of service processes, such as improvements in nursing care [1].

In this paper, we present a study on students' experiences of a project learning concept called ICT ShowRoom. ICT ShowRoom is an annual student project exhibition and competition organized by three different universities in Turku, Finland. ICT ShowRoom is distinguished from other project learning methods in three ways. Firstly, there are participants from three different universities. Secondly, mentors and most of the assignments are real-life projects and some topics are given by companies. Thirdly, the exhibition and competition finally brings together a multidisciplinary group of students and experts and is a good networking event. The research was carried out by conducting eight group interviews and by implementing a participant survey questionnaire (N=168) during the 2013 exhibition event.

2. Innovation as a learning platform

In the innovation process knowledge is used for creating new artefacts or improving existing ones. the innovation process can be seen as a knowledge transformation process from an idea to a (technical) system, and the system is formed within the limits of the designers' (all students involved) cognitive and information capacities [2]. The innovation process is always unique and specific, and thus available knowledge must be applied to support the case. The first paradigm of the innovation process was 'technology-centred', the second wave was 'user-centred', and the present can be named 'systems-centred'. This change means that the design team needs a holistic view about the problem and solution space. The more deeply designers understand the users and the use context of the product or service, the more they are able to discover the needs of customers. Therefore, besides the technical requirements, the environmental factors and users' psychosocial needs are more and more essential sources of information for the new products or services. Knowledge is not only applied to develop product functions or features but it gives a broad pre-understanding about the problem backgrounds and alternative solutions [3]. Our mission is to educate new generations of professionals whose conceptions of producing, adopting and utilising knowledge make innovative thinking and creating innovations possible.

A learning environment is most frequently understood as the physical or virtual surroundings meant and built for learning purposes. As well as the current participatory approach [4] that joins many different stakeholders in the innovation process, a social learning environment is formed by people with different talents and competencies. In a social learning environment, individual knowledge is still important, but sharing the knowledge is crucial. In the innovation process the social aspects of team work and knowledge acquisition are enabling collaborative learning [5]. Akgün et al. [6] have stated that collaborative knowledge acquisition and sensemaking within the team increase team intelligence, which helps the team members to understand each other. It facilitates learning and the team's ability to convert problems into more versatile solutions. Information sharing and collaborative sensemaking aim to encourage team members to communicate and negotiate with others to ease decision making and problem solving.

Creating innovations presupposes knowledge and the ability to apply it. Innovation pedagogy [7] [8] is a learning approach that defines in a new way how knowledge is assimilated, produced and used in a manner that can create innovations. In innovation pedagogy the social aspects of learning and working are emphasised and project-based learning methods where learning happens in multidisciplinary teams form an essential share of the studies. The traditional view held by universities is that students receive new information and skills as a student and only begin to apply it in the innovation processes after finding employment. This type of thinking innovation pedagogy wants to challenge by highlighting that knowledge should be utilised in innovation processes already while studying. In other words, from the learning viewpoint, knowledge should be accumulated and applied simultaneously. Innovation pedagogy appears as an interactive effort between the educational organisation, students and surrounding working life and society forming a social learning environment. The aim is also to make the knowledge transfer more efficient from the university environment to the actual working environment and vice versa. In this environment, it is possible for students to participate in local innovation processes and learn the required innovation skills.

In the production of innovations two closely related concepts are connected: learning and developing. They often appear as two aspects of the same concept. The student can learn several issues in the innovation process, covering, for example, tacit knowledge, networking, shared expertise and challenges to meet uncertainty. At its best, innovation is an inspiring and challenging learning environment for the learner. When developing innovations, the students recognise the information that is supposed to be found through studying. Innovations also include the risk of failure, which is an integral part of development in the context of working life. Facing risks and failures is valuable capital which a student can acquire when working with innovations [1].

3. The ICT ShowRoom concept

The information and communication technology departments of TUAS, University of Turku and Åbo Akademi University (all located in Turku, Finland) moved their activities into the same building in 2006. This created a joint campus for students, faculty members and staff. As one of the co-operation efforts, the ICT ShowRoom, a joint competition between the student projects that focused not only on technical implementation details but also on the business ideas behind the projects, as well as on the presentation skills of the teams was launched. The intention was to create an event with a good spirit and a relaxed atmosphere – but still set up a real competition with considerable prizes for the winning team. The planning of the first pilot implementation was started in late autumn 2007 and, finally, 42 teams presented their work at the first ICT ShowRoom exhibition in March 2008.

The event accepts two kinds of contributions: student projects conducted during the past year as part of coursework in one of the departments (projects from other institutions can also be accepted), and research project presentations. For both types of contributions, the organisers provide a poster stand and a table for demonstrations. For the student projects, the organisers print the posters and cover the printing expenses. The student projects participate in the competition part of the event, where a jury evaluates each participating student project and selects a winning team. In order to have a non-biased jury, a group of local industry professionals act as members of the jury and sponsor the prizes given to the winning team. The jury assesses the technical contribution and quality, commercialization potential and presentation of the student projects. In addition to the student project competition, the event also includes a public vote in which visitors to the event may vote for their favourite presentation and technical content.

The ICT ShowRoom event has now been organised six times with only minor changes between the rounds, and the experiences have been very positive. It has become an integral part of the academic year gathering students, staff and industrial representatives together. The ICT ShowRoom event has clearly grown into a multi-institutional and interdisciplinary workspace that "supports and encourages hands-on learning of product and system building, disciplinary knowledge, and social learning." [9] The event and the student projects facilitated by it serve as a networking platform for students, the university faculty and staff, and also local companies. The ICT ShowRoom concept and its development history have been reported in detail by Björkqvist, Roslöf and Virtanen [10] [11].

4. ICT ShowRoom 2013 participant questionnaire

In order to study the overall experiences of the ICT ShowRoom 2013 participants, a small feedback questionnaire was included with the public voting form for the event. First, it was asked whether the respondent was a student participating in the competition, a student not participating in the competition (just visiting the event), a company representative, or a member of university staff. Next, the respondent was asked to describe the event with three freely selected adjectives. Finally, those who were not participating in the competition were asked if they would like to study this way, and the competition participants were asked what they thought they had learned during the process. Participation in the survey was voluntary and it was possible to join the public voting also without answering the questionnaire part of the form.

Altogether, 168 persons submitted the form (59 students participating in the competition, 69 students visiting the event, 9 company representatives, 21 university staff members, and 10 without category information). 93 (55%) responded to the questionnaire part of the form (38 students participating in the competition, 44 students visiting the event, 4 company representatives, and 7 university staff members). The competition had 137 participating students, i.e. 28% of the participants answered the questions. The number of event visitors was not monitored, but the exhibition was certainly attended by hundreds of visitors (mainly students). That is, the general response rate for the survey was not high but it still provides an interesting qualitative perspective on respondents' thoughts concerning the ICT ShowRoom 2013 event and the project activities before the exhibition day.

The descriptive adjectives (not all of them are actually adjectives) given by respondents are presented in Table 1. The results are categorised according to the type of respondent and the number after each word denotes the number of times the word appeared in the responses. Themes indicating interest, excitement and usefulness dominate the answers in all categories. Only a few words reflect negative feelings connected to the workload, stress, frustration and complexity, for example.

Table 1. Adjectives used to describe the ICT ShowRoom 2013 event

Students participating in the competition		
fun (13)	innovating (2)	incredible
innovative (12)	motivating (2)	informative
interesting (12)	positive (2)	intense
good (4)	smart (2)	international
inspiring (4)	versatile (2)	lively
popular (4)	active	long
useful (4)	best	massive
cool (3)	creative	prospective
crowded (3)	educational	raw
exciting (3)	effort	relaxed
nice (3)	elegant	shameless
yay (3)	full	unique
busy (2)	helpful	wannabe important
convenient (2)	important	warm
friendly (2)	impressive	very good
Students visiting the event		
interesting (17)	appealing	good graphics & poster
fun (15)	best	high
innovative (8)	busy	ideas
informative (6)	cheerful	intelligence
exciting (3)	crowded	intriguing
inspiring (3)	curious	mind-blowing
nice (3)	developing	motivating
useful (3)	easy	network
complex (2)	educating	powerful
cool (2)	educational	prototypes
creative (2)	enchanting	reliable
helpful (2)	entertaining	sophisticated
modern (2)	fascinating	speed
pretty (2)	freebies	stimulating
simple (2)	friendly	sugar
active	funny	teaching
advanced	good	vibrant
amazing		
Company representatives		
interesting (2)	inspiring	real
crowded	international	refreshing
educating	modern	useful
has-potential	nice	
University staff		
interesting (3)	fascinating	nice
awesome	good	open
cool	informative	rich content
diverse	innovative	too short
exciting	inspiring	useful

In total, 44 (87%) respondents who did not participate in the competition themselves replied to the question concerning their own interest in studying like this. Only three replied that they are not interested in this type of opportunity and five were unsure. All other replies (36; 82%) were clearly positive and indicated interest in studying in innovation projects.

The competition participants' answers to the question on what they had learned during the process are summarised in Table 2. Altogether, 34 students (89%) replied to this part of the questionnaire. The results are sorted using three different themes: Technical knowledge and skills (traditionally defined), other knowledge and skills, and 'other replies'. The same or nearly the same topics have been merged in order to improve the clarity of the table. The number after the topic indicates how many times it was mentioned in the answers.

Table 2. ICT ShowRoom 2013 participants' experiences on what they have learned

Technical knowledge and skills	
game development (3)	Unity platform
programming (4)	Vaadin platform
scripting skills (2)	
Other knowledge and skills	
team work (8)	always meet people's demand, value added
project management (7)	hope for the best and prepare for the worst
presentation skills (5)	making a poster
communication (2)	patience
be prepared for presenting your project with expertise, know what you are talking about	product development
	representing
business	stick to schedules, keep your team well informed
communicating with a real company	talking to people
cooperation with different people from different countries	to present the idea of our project
Other replies	
a lot (4)	not much
many things (2)	

The results indicate that relatively few respondents mentioned that they had learned technical knowledge and skills during the competition and the project courses. Instead, topics in collaboration, project management as well as communication and presentations skills were listed by many students. Although it is probable that most of the participants gained new knowledge and skills also connected to the technological contents of their project, the 'other side of the coin' clearly dominates the experienced learning focus. Many of the students participated for the first time in this type of exercise, typically with a complex, open-ended and dynamic assignment and a need to co-ordinate tasks with a team during a longer period of time. As a result, the parts that were experienced as most challenging and also useful dealt with these themes.

5. Student interviews

In addition to the survey, a total of eight teams were interviewed (n=36) to get deeper insights into not only the ICT ShowRoom event, but also the study project as a whole and learning experiences during the process. The ICT ShowRoom event is the highlight and the final stage of often long and laborious projects, which last one or two semesters. The interviews were conducted as personal interviews. They were not recorded, but thorough notes were taken and quotes were documented. Photographs were also taken. The interview questions were:

1) What is the name of the team and the fields of study?
2) What is your project idea?
3) How did it develop?
4) Did you get help from the university?
5) What motivated you?
6) How do you feel about this way of studying?
7) Any other comments?

The respondents were divided among the universities according to Figure 1:

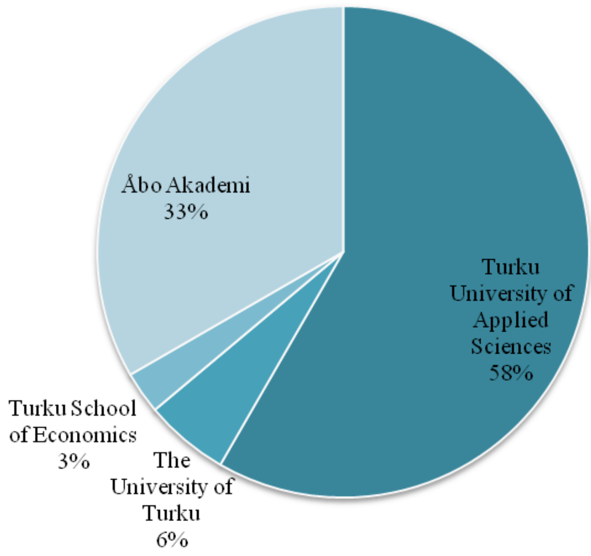

Figure 1. The distribution of the respondents between the participating universities.

The extent of the project courses varied from 5 to 15 credits (European Credit Transfer System; 1 credit = 27 hours of student workload). For some students participation was compulsory, while for others it was voluntary. There was also variation in whether the students had an assignment from a company or if they developed the idea for the project themselves. When asked about the students' motivation for participation, many of the answers suggested that project learning is useful and the students felt like they were learning practical things.

> *"I get coding experience and useful contacts."*

> *"First, the study credits, but then we noticed that our idea is actually very good and we got really excited!"*

> *"Learning by doing, I feel that I'm really learning something."*

> *"This is the most practical thing you can do at the university. But also the scariest. I also wanted to meet Finnish students."*

Many of the answers revealed that the students did not use the mentoring and coaching which was available, but they rather worked on their own through trial and error. Technical support would also have been available. When asked about learning, the respondents did not emphasise technical skill but rather stressed that they learned about seeking information, project management and multidisciplinary teamwork.

> *"The fact that you get to do something concrete is motivating. Normally, we don't interact with the other students that much, now we got a wider perspective. In this project, you get to throw ideas around freely without the teacher breathing down your neck. This way it's easier to come up with ideas."*

The students came mostly from different ICT-related degree programmes, with a few exceptions. The respondents' fields of studies are presented in Figure 2:

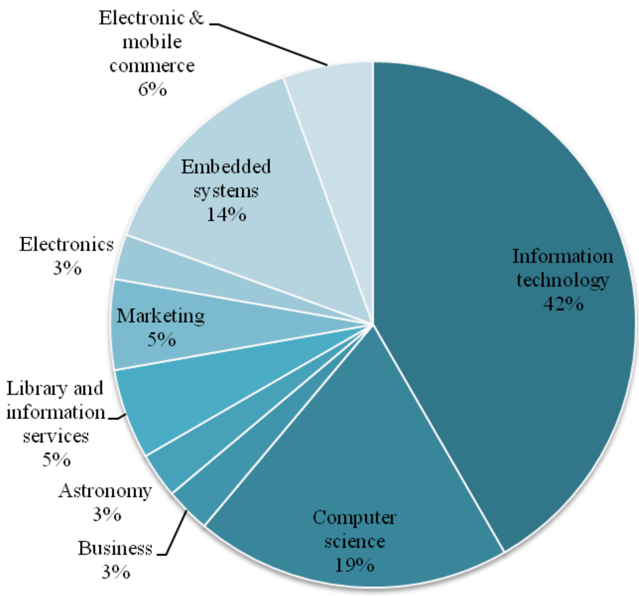

Figure 2. The respondents' fields of study.

In the idea phase more tools would have been needed. None of the universities offered coaching in innovation methods directly connected to the project courses. The students had used methods such as brainstorming, 5 x 5 ideas, Business Model Canvas, SWOT and trial and error.

> *"I think this is the most comfortable way to study when you have to acquire knowledge yourself. My own thinking developed when we got to try practical things. We didn't have any guidelines, so we had to discover our own ways of doing."*

Almost all the respondents were excited about the programme and emphasised that hands-on, real-life projects feel more meaningful compared to some other courses. Also, practical experience and getting useful contacts was mentioned. Many of the students also said that they developed their teamwork and social skills. Thus, the biggest motivator was not the credits but learning by doing.

> *"If you are motivated, you can learn a lot, but if not, then you don't learn anything. We learned how to seek answers ourselves. We know that in working life no one will give you the ready answers. We also learned how to use a new programming language."*

> *"The project felt really good. You learn by doing. It was good that we had a real client instead of an imaginary project inside the school. It was much harder this way, but it didn't matter that we had more work."*

6. Conclusion

In this paper, the role of the innovation process as one of the central learning platforms in higher education was discussed. In addition, the ICT ShowRoom project learning concept was described, and a study on the experiences of students participating in the ICT ShowRoom 2013 was presented.

It can be stated that study projects like the ICT ShowRoom increase students' innovation competencies and develop skills such as project management, new ways of thinking and spontaneity. The survey results comply with the interviews. For example, most of the survey respondents described the event using positive adjectives and indicated interest in studying in innovation projects. Also, the students interviewed spoke about positive learning experiences. The survey as well as the interviews revealed that technical learning was not the primary motivation for participation. Students valued abilities such as problem solving skills and presentation skills more. However, it is probable that working with an innovation project also developed the students' technical knowledge and skills, although this dimension was not explored in more detail in this study.

Based on the interviews, it seems that participation in the project course did not directly encourage the students to become entrepreneurs. Rather, it developed their motivation towards intrapreneurship (*sic*), i.e. behaving like an entrepreneur while working within a large organisation. This is also an excellent result. As a result, ICT ShowRoom has succeeded in creating an inspiring and challenging learning environment where learning is done through trial and error.

This study has some limitations due to the quite small amount of information gathered by the survey questionnaire and interviews. In any case, the results of the study support the findings that students can learn several things in the innovation process, covering, for example, tacit knowledge, networking, shared expertise and challenges to meet uncertainty. At its best, innovation is an inspiring and challenging learning environment for the learner: developing is like being at the frontiers of existing knowledge and abilities, reaching out for the unknown.

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Presenter: The paper is presented by Tiina Jaatinen

Teaching information security concepts: an observational study of student mobile phone users

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Abstract

The ubiquitous usage of mobile phones has transformed how people communicate, interact with businesses and access information. While new mobile phone developments may be positive and predominantly beneficial to mobile phone users, securing these mobile systems and services remains a challenge. An increased amount of personal information is stored on mobile phones which creates global consumer information security concerns. In view of these growing concerns, many universities have incorporated a computer security module into the curricula for computer related courses. The main concern of this paper is that traditional methods of teaching these information security centric modules do not result in improved security practises amongst students, as they struggle to internalise difficult material. Action research was used in this study to explore the relationship between students' knowledge or awareness of information security concepts and their perceived or actual information security behaviour. The findings show that the level of student information security awareness is poor and this is confirmed by the assessment results for the module. To promote the effectiveness of teaching information security concepts, this paper explores the possibility of using mobile applications in teaching information security concepts and suggests a systematic approach lecturers' can follow prior to introducing these applications in the classroom.

Keywords: *Information security education, Information security practises, Student mobile phone applications.*

1. Background

Transforming the South African higher education system was a key focus area for a post-apartheid government. One year after the election of the first democratic South African government, a commission (National Commission on Higher Education) was formed which led to the drafting of two guiding documents aimed at addressing the transformation targets by redressing historical imbalances [1]. As identified in the White Paper, the main challenge facing higher education is redressing past inequalities and transforming the higher education system to serve a new social order, to meet pressing national needs, and to respond to new realities and opportunities. In 2002 a proposal for the consolidation of higher education institutions through mergers and incorporations was approved by government [2], which resulted in the higher education systems being constituted of eleven universities, six comprehensive universities and six universities of technology. The participants of this study are students of a comprehensive university structure formed in 2005 by merging two 'historically black' technikons and a university. The Draft National Plan for Higher Education in South Africa [3] justly makes references to the demographic profile of the student body, where teaching under-prepared students is an inherent characteristic associated with the 'historically black' institutions. While the landscape of most 'historically white' institutions is gradually becoming more representative of the South African population, the approximately 21000 strong university student population represented in this study is primarily made up of Black African students. The geographic spread of the four university campuses is across three towns in the Eastern Cape Province, and a round trip between all three campuses is 737 kilometres covering a band of urban and the bulk of the province's rural areas. During the merger planning and execution for the university, various challenges were raised such as the availability of resources and infrastructure. Other challenges unique to this environment which can impact the effectiveness of teaching information security principles include: language (with the lectures being presented in English to students who are second language speakers of the language), availability of computer resources and merger related environmental disturbances (e.g. curriculum changes, strikes which result in loss of lecturing time). Understanding the environment in which the study was conducted has implications not only for the generalisability, but also for the interpretation of findings.

Whilst this paper does not attempt to address the merger related challenges of the university, it explores the possibility of using mobile phones as technological devices that the majority of students have access to in order to facilitate the teaching of information security related principles. The South African mobile telephony market is one of the fastest growing in Africa. The meteoric increase in mobile phone adoption in South Africa is substantiated by the results of the census carried out in 2011 by Statics South Africa [4], which reports that the percentages of households with mobile phones in working condition have increased from 32.3% in 2001, 73.3% in 2007 and 88.9% in 2011. Comparing mobile phone adoption to the percentage of households with a computer which rose from 8.6% in 2001 to 21.4% in 2011, it is evident that mobile phone reach has far exceeded that of computers in South Africa. Mobile phone market volume figures show that in the year 2011 there were approximately 28.8 million mobile phones in South Africa. With Statistics South Africa reporting a population size of 57.1 million in 2011, it can be inferred that there are arguably enough mobile phones in South Africa to supply one to nearly 50% of the South African population. However, the accuracy of this assumption could be questioned as in some cases one person owns more than one mobile phone or mobile phone sim card. A more illustrative figure is the 88.9% of South African households have mobile phones calculated by Statistics South Africa.

The mobile reach is not only limited to households. The findings of this study show an even better ‘uptake’ rate amongst the participants of this study with 100% of them owning mobile phones which they carry to campus daily. Educational researchers encourage the use of mobile applications (including social networking websites) to support learning in the classroom. This paper proposes that while there is evidence to indicate positive results in various contexts, in order to improve their effectiveness a strategic process must be followed by lecturers prior to introducing these mobile applications in their classrooms. Teaching students information security principles has become a crucial component of any Information and Communication Technology (ICT) related training as humans are repeatedly identified as the most important factor to be considered in securing information assets. People use technology in one of two environments: the workplace and home [5]. The mobile phone user considered in this study falls into the latter group of technology users. Due to poor levels of knowledge about information security threats they are exposed to in their environment, mobile phone (home) users pose the biggest threat to information security [6], [5] with some security breaches (virus infections, identity theft, dumpster diving) being a direct result of user carelessness or lack of action [6]. A strange behaviour is observed amongst mobile phone users who in some cases are aware of the threats that could be exposed to and still don’t exhibit safe information security practices security when using their mobile phones [7].

ICT is recognised as an enabler for teaching and learning [8] poised to compliment traditional teaching methods [9]. In examining the link between information security awareness and information security teaching modes, the literature findings show that mobile phone applications can potentially be used in the educational environment to positively influence the information security practices of students. Mobile phones can be valuable in higher education, and the next section indicates that they can influence how information is gathered and used, communication, time management and improved engagement with learning [10].

2. Mobile phones in the classroom

Since 2006 when researchers explored the use of short message services (sms) to encourage interactivity in the classroom [11], the ever increasing role of mobile phones in the classroom has become unavoidable. While the mobile learning approach taken by most researchers is through introducing ‘tailor-made’ applications, the social networking phenomenon has swiftly propelled both the lecturer and student into a new level of interactivity. Considering the challenges (student access to devices that support the applications, costs associated with developing these applications [10]) of the former approach, social networks can be readily accessed by most students. The social networking mix of Facebook, Blackberry Messenger (BBM), WhatsApp and MXit has different adoption considerations for student mobile phone users. Social networks provide an affordable way to communicate and students are already using social networking sites to chat socially and to support their academic life informally [12]. Undeniably there are obvious advantages (most relating to improved ability to communicate and collaborate [12]) and certain disadvantages (such as online communication being less satisfying than 'face-to-face' communication [12]) of using social networks in the classroom. However, they caution that use of social networks in the classroom will be unplanned and random interactions that do not contribute to constructive learning if an integrated strategy is not considered. Social networks present the opportunity of an 'anywhere, anytime' educational experience in which the student is seen as a co-creator of knowledge [13]. However, if their introduction into the classroom is not properly planned for, its potential impact will be diminished. In using mobile phones in an information security classroom lecturers cannot use a 'one size fits all' approach. The following questions must be addressed:

1. *What do the students already know?*
2. *What are the mobile applications options available which can be used in the classroom?*
3. *Which applications will be the most suitable for use with a particular class/group of students?*

This study suggests that in the case of teaching information security related concepts to students, the benefits of incorporating social networks will outweigh the disadvantages. However, lecturers are advised to proceed with caution prior to promoting the use of social networks as an additional teaching/learning resource. Careful consideration must be taken to: understand the existing levels of information security awareness understand the social networking landscape (available social networking sites), and know which social networking sites can be accessed by students on their mobile phones. A brief discussion on information security awareness follows.

3. Information security awareness *(What students know)*

A distinction can be made between two groups of technology users, namely: Home Users and Non Home Users [14]. Adopting their definition of a Home User, this study views mobile phone users as Home Users who use technology at home, and are self-responsible for securing their mobile phones against possible threats. A major cause for concern with Home Users is that unlike with Non Home Users, there are no regulatory bodies to enforce that they obtain information security awareness knowledge and implement it [15]. Researchers should exercise caution and not presume that by simply telling people the relevant information security facts that mobile phone users will change their behaviour [15]. Mobile phone users lack the ability to derive meaning from the information and apply it [15].

Security awareness training must move away from traditional approaches of Power Point dependant classroom lectures [16]. Three elements that must be considered for successful security awareness initiatives are: Attention, Retention and Motivation [16]. Raising awareness is an important step, however, it is not sufficient for overcoming all the hurdles/challenges and it does not always result in improved security behaviour [17]. The ultimate goal of information security awareness is to be awareness of security threats, understand how these threats work and be able to predict/anticipate potential outcomes if the threats are ignored [6].The information security module assists in addressing students' confidence, capability and understanding of the technologies. Mobile phone applications can be used to influence their perceptions, priorities and sense of security responsibility. The next section discusses some of the mobile applications (social networking sites) which can be found in most mobile phones.

4. Mobile phone applications *(Available options)*

The accelerated new developments in the mobile phone hardware technologies have created limitless opportunities for new mobile applications (mobile apps). Improved mobile phone services can be attributed to improved hardware (embedded sensors, memory, power consumption, touchscreen, and better ergonomic design), software (more sophisticated applications are possible due to the release of the iPhone and Android operating systems), transmission (higher data transmission rates achieved with 3G and 4G technologies), and access to Wifi networks [18]. There are two ways of exploiting the mobile phone benefits [19] of "collaboration and sharing of information with considerable ease" [18], by using mobile apps or mobile websites.

Mobile apps are software applications developed with a specific operating system [19]. The applications which run on the mobile phones are dependent on the operating system installed. The following examples of mobile phone apps and services can be identified [20]:ubiquitous communication (e.g. email, sms); content deliveries (e.g. health-related messages, reminders); entertainment services (e.g. music, gaming, gambling, sports scores); location-based services (e.g. tour guides, finding nearby facilities, transportation information) and general applications (e.g. ticketing, store/restaurant discount coupons, shipment tracking, banking, and bill payment). With thousands of mobile apps available for download, an additional category for network communication can be added [21] which includes social networking (e.g. Facebook, Twitter) and instant messaging (e.g. MXit, WhatsApp). Mobile apps are one of the most useful features of a smartphone or tablet [22]. Researchers suggest that games are the most popular apps followed by weather, navigation and social networking [23]. However, while many people are familiar with mobile apps for shopping, games, and social networking, there are more apps to explore than just the apps for recreation [22]. Despite the limitation of mobile applications being operating system specific, and judging by the accuracy of the predictions [24] about software applications for mobile devices being the next trend in technological innovation, researchers' opinion that mobile access to networked information will surpass desktop web access ([19], [25]) will likely prove to be accurate. The mobile app is preferred over mobile websites as they don't involve the clutter of domain-name servers and uncalibrated information sources and take the user straight to the content they value in one-click, unlike a mobile website [19],[23].

A study was undertaken which sought to determine students' existing levels of information security awareness and to identify which mobile applications would be most suitable for the study population. The data collected was analysed and some of the findings are summarised in this paper. The following section details how data was collected.

5. Methodology

Action research was identified as the most suitable design for this descriptive and explanatory research study. Action research is a form of self-reflective inquiry undertaken by participants in a social situation to improve the rationality and justice of their own practice [26]. This inquiry sees the researcher devise a plan and executing an intervention which will result in some change (improvement) to benefit the study's participants. In observing the results, data is then analysed from which conclusions can be drawn upon reflection. As action research gained acceptance in the applied fields, John Dewey pioneered the application of its principles in the field of education. Dewey's transformed view of the classroom as a democratic community where lecturers are encouraged to focus on encouraging student reflection and improvement is impressive [27]. It is further proposed [28] that Dewey's views on the importance of human experience in the generation of knowledge formed the theoretical basis for action research in education. Educationalists recognised the potential of action research in producing knowledge which can be of practical use, and subsequently using it as a method for improving educational practice [29]. In the case of this study, action research was used to observe the information security behaviour of students before and after using various interventions aimed at stimulating positive information security practises. This paper summarises the findings observed after lecturers (*intervention*) on information security principles which were presented to the participants. The syllabus includes a chapter on '*Privacy and Security'*. This chapter provides a formal introduction to information security related concepts. The chapter is divided into two sections namely: *Privacy* and *Security*. The section on privacy, which deals with the privacy concerns for organisations and individuals, covers the following topics like: Protection of databases and networks *(information resellers, identity theft, employee monitoring software, keystroke loggers, packet sniffers),* the Internet and the Web *(cookies, spyware, antispyware, online identity)* and major laws on privacy. The section on security deals with topics like: cybercrime *(viruses, worms, Trojan horses, hackers, cracker, malware, phishing scams, denial of service attacks, spam, social engineering, pharming, botnets, zombies)* and measures to protect computer security. A summary of the chapter was presented in class. The students were encouraged to comment and ask questions during these sessions. During these sessions the link between the study and the participant's understanding of information security as a topic, which not only afters how they relate to technology, but also as an examinable topic which forms part of the syllabus, was highlighted. The findings of the survey and observations are summarised in the next section.

6. Results and discussion

Creating a student population profile based on the 'merger' related challenges mentioned earlier is beyond the scope of this study. However, for the purposes of this study it is sufficient to note that all the participants own a mobile phone, are given instruction in a second language, and they have limited access to computer resources even in on-campus computer laboratories. The ages of the participants range from 18 to 41 years. While 90% of the participants are below the age of 25, the majority (56%) are aged between 20 and 21 years. Fifty two percent of the respondent's first contact with computers was at university.

6.1 What students know:

Questions were asked in the survey to determine the respondent's general knowledge of common mobile phone security related terms including: definitions of phishing, spam and antivirus software as well the application of Bluetooth, mobile phone memory cards and a mobile phone lock code. Figure 3 below summarises the percentages of respondent who selected the correct answers from the multiple choice options given relating to each question:

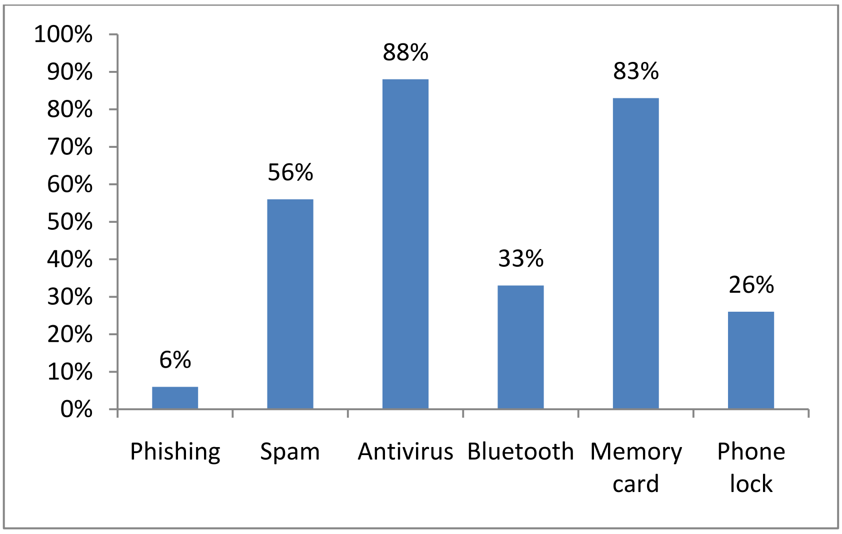

Figure 1: General knowledge of mobile phone security related terms

The respondents showed a good understanding of what antivirus software (88%) and memory cards (83%) are used for. Surprisingly, the majority of them were uncertain of antivirus software application to the mobile phone context. When asked if they used antivirus software on their phones, 30% were of the opinion that their phones did not have the functional capability; 43% did not know if such a product was available for their phones; 20% knew antivirus software was available for their mobile phone but they did not use it, and only 8% claimed to use antivirus software on their mobile phones. One would then assume that these responses contradict the results which showed that 88% of the respondents had a good understanding of what antivirus software is. However, the case may be argued that while the respondents generally have a good understanding of the term, they may not have internalised the information/knowledge to an extent where they see it as applicable to their own mobile phones.

The correct definition of spam was selected by 56% of the respondents. With 89% of the respondents accessing the Internet on their mobile phone, the spam levels of awareness is a cause for concern. While only 33% and 26% of the respondents knew how Bluetooth and Phone lock codes were respectively used. Password protection (Phone lock) is a practised by 68% of the respondents. It is worth noting that only 26% of the respondents indicated they knew what a phone lock code was used for, yet the percentage of respondents using a Phone lock code is 68%. This raises the possibility that 42% of the respondents adopted the behaviour (password protecting their phone) without fully understanding what it means. This observation gives us an early indication of the discrepancy between what the mobile phone user knows and their information security behaviour.The low percentage for the number of respondents who know what Bluetooth is used for, is another cause for concern as only 25% of the respondents admitted that they do not download software/files to their phones. Unlike the previous case where the respondents had adopted a ‘safe’ information security behaviour without understanding, in the case of using Bluetooth the majority of respondents have adopted an ‘unsafe’ information security behavioural practise without fully understanding how Bluetooth can be used. Phishing proved to be the least understood concept with only 6% of the respondents selecting the correct definition for Phishing. Behaviour similar to that of using Phone lock is seen with the majority (79%) of the respondents opting for ‘safe’ information security behaviour by ignoring a bank related Phishing email or calling the bank to verify the email’s authenticity.

A Likert scale was used to determine respondents’ understanding of terms specifically related to information security such as: *virus/worm, Trojan horse, spam, social engineering, phishing, pharming, identity theft, key loggers, botnets, zombies, denial of service, packet sniffers, hacker, zero day attacks, cracker* and *malware*. The three-point scale was designed to trigger more precise responses by giving respondents the following options relating to each term: ‘understand what it means’; ‘heard about, but don’t understand’ or ‘never heard the term.’ The confirmatory responses for complete understanding are summarised in Figure 4 below for each security related term:

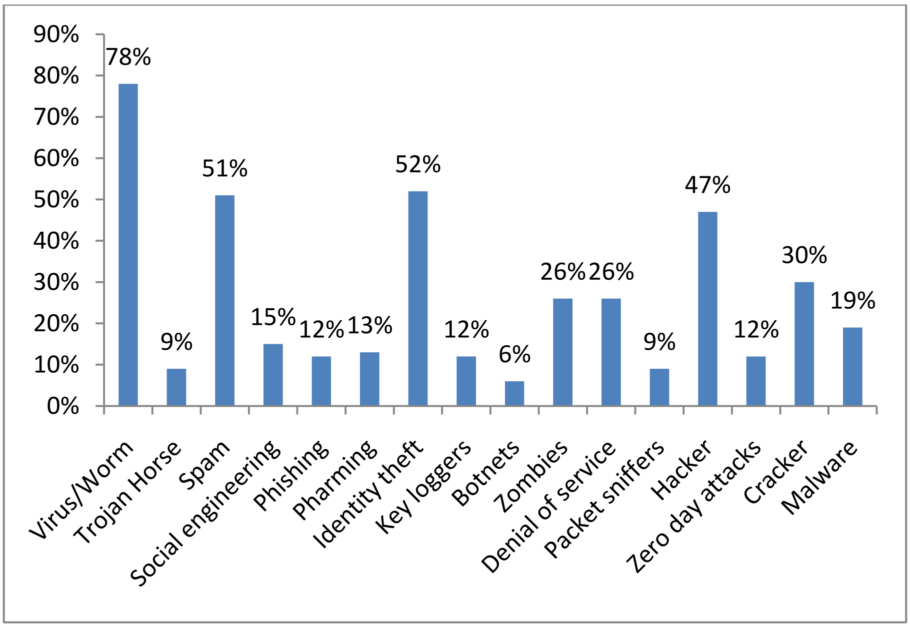

Figure 2: Understanding of information security related terms

With the exception of *Virus/Worm*, *Spam* and *Identity theft*, the respondents had average low level of awareness of all the other information security related concepts. In the population represented in the survey, Figures 3 and 4 give a good view of students’ level of awareness of various information security related terms. These terms were extracted from the syllabus and can therefore be used by the lecturer in planning for a mobile application intervention to guide where emphasis must be placed.

6.2 Available/suitable mobile application options:

The findings also showed that students in the study population had a mobile application 'mix' which is made up of the following social networking and instant messaging applications: Twitter, WhatsApp, MXit and Facebook. One should avoid the trap of selecting a mobile phone application to be used in the classroom prior to checking 'which applications will be most suitable for use with each class/group'.

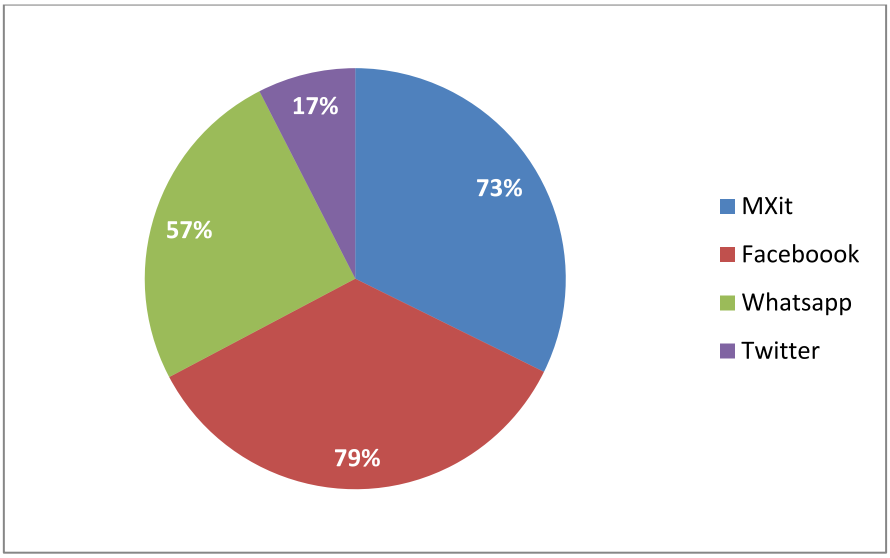

Figure 3: Student mobile phone application usage

The most popular for the population studied is Facebook with 79% of the respondents using the application on their mobile phones. MXit is a close second with 73% of the respondents using the application. WhatsApp and Twitter are used by 57% and 17% of the respondents respectively. Based on the data the lecturer would then choose the best option between Facebook and MXit, considering any factors which might discourage use of one or the other by students (e.g. price).

Overall, the only security related concept most participants indicated a good understanding of what a virus/worm is, and they also knew the possible uses for antivirus software. In the general knowledge of common mobile phone related questions the results showed that while students are in possession of their mobile phones for the greater part of the day, they barely pay attention to some of the features on the phones or how these features could expose them to information security threats. In teaching information security concepts to this particular group, attention must be given to explaining technology features and other specific information security terms (not just viruses). In deciding on whether to use mobile applications the lecturer must explore the available options. The costs associated with acquiring/developing customised mobile learning technologies would be a strong deterrent in the case of the selected university. Social networking or instant messaging applications would be the most feasible. All the participants use some form of social networking or instant messaging application. Although Facebook may be slightly more popular, the limitations relating to the data costs of using Facebook are much higher than using applications like WhatsApp or MXit. The suitable application to use with this group of students is MXit. Young people are generally considered to be 'techno-savvy' with the common assumption being that they have an almost 'intuitive' ability of adapting to new technologies. The survey results show that lecturers cannot rely on assumptions when it comes to students' awareness of information security principles nor the most popular mobile phone applications for use in the classroom environment. Knowing their initial level of information security awareness and determining the most suitable mobile phone application to be used with a particular group, will help to improve the effectiveness of teaching information security principles.

7. Conclusion

The findings showed that in certain instances what the students know contradicts their information security behaviour. This anomaly found amongst student mobile phone users, who are taught a module on information security concepts where technology related threats, risks and countermeasures are discussed in detail, shows they continue to exhibit low levels of information security awareness and poor information security behaviour. While universities offer courses which introduce students to information security principles, risks and countermeasures, the lecturing approach does not give students an opportunity to internalise the material presented in class. This paper suggests that a strategic process must be followed by lecturers prior to introducing mobile applications for learning, when teaching information security concepts.

This paper proposes that a structured approach must be followed by educators when introducing mobile phone applications (social networking) in the learning and teaching environment. The findings of this study clearly show that there is diversity when it comes to the mobile phone applications used by different students within the same group. In teaching information security concepts, the educator's choice of which mobile phone application to use must be based on the applications which that particular group of students all have access to. In some instances the suitable option might be a combination of mobile phone applications. Admittedly, using mobile phone applications as a teaching strategy has limited application as it cannot replace the value added by attending lectures. Mobile phone applications (social networking) can complement the normal teaching activities when they are used to recap or highlight some important topics from the syllabus and create a dialogue between students and lecturers that continues beyond the scheduled classroom periods. For this dialogue to be effective, the lecturer must also gain an understanding of the students' existing knowledge levels of information security concepts. This is instrumental for determining which topics to prioritise when using the mobile social networking applications.

In an environment characterised by a scarcity of resources, introducing mobile phone applications in the classroom can be a cost free strategy which can result in the improved effectiveness of teaching information security principles to students. Prior to introducing mobile social networks in an information security classroom, lecturers must determine the student's level of awareness, check the available options of mobile social networking applications, and know the social networking applications that can be accessed by a particular group of students using their mobile phones.

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Presenter: The paper is presented by Bukelwa Ngoqo

Logic and Cognitive Complexity as Indicators of Progression and Articulation: The Case of Vocational and Professional IT Qualifications

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Abstract

This paper reports on the results of a case study to investigate articulation and progression between vocational/professional Information Technology qualifications at levels 4 to 7 of the South African National Qualifications Framework. The curricula of four learning programmes were analysed, viz. the National Certificate Vocational (Information Technology and Computer Science) offered by Further Education and Training Colleges, and the Higher Certificate, National Diploma and Bachelor of Technology Degree in Information Technology as offered by the Nelson Mandela Metropolitan University. The analysis was undertaken using an explanatory framework which suggests curriculum logic and cognitive complexity as indicators of progression and articulation. The framework views principled (conceptual) and procedural (contextual) knowledge at the two extremities of a continuum and using this, attempts to identify curricular logic within the learning components of programmes. An analysis to determine the cognitive complexity in the programmes then identifies modules that require recall (low complexity), explanation (medium complexity) or application of the concepts (high complexity). While providing interesting insights about articulation and progression between the learning programmes that were investigated, the research also demonstrates the utility of the framework that was applied in the execution of the research.

Keywords: *Curriculum logic, Cognitive complexity, Information Technology curriculum, Progression and articulation.*

1. Introduction

The South African Higher Education (HE) sector has been subject to major restructuring in the last decade. This restructuring was initiated in terms of the South African National Plan for Higher Education, published in 2001 [1]. In the briefing on the National Plan for Higher Education by then Minister of Higher Education, Prof Kader Asmal, he indicated that higher education in South Africa did not meet the needs of society and that there was a need for restructuring and diversifying the higher education system. In the ensuing period, the total number of public Higher Education Institutions (HEIs) was reduced from thirty-six to twenty-three, resulting in eleven traditional universities, six comprehensive universities and six universities of technology.

Two of the newly created comprehensive universities, the Nelson Mandela Metropolitan University (NMMU) and the University of Johannesburg, subsequently embarked on a process to develop a consolidated programme and qualifications framework for each university, given the undefined nature of a “comprehensive university” at the time. This work was funded by the South African Norway Tertiary Education Development (SANTED) programme. The main aim of the project was to develop a conceptual framework for curriculum differentiation between qualification pathways. The results of the overall project is reported in [3]. One of the sub-projects of the SANTED programme (Phase 1) investigated Information Technology (IT) programmes offered at the NMMU. A conceptual framework for curriculum differentiation had been developed and a call was sent for volunteers in a pilot project

(SANTED Phase 2) to test the framework at the NMMU. This paper reports on the results of one of the Phase 2 pilot projects, in particular the pilot conducted to investigate articulation and progression between vocational/professional Information Technology qualifications at levels 4 to 7 of the South African National Qualifications Framework (NQF).

At the time, discussion and debate around the role of colleges in the Further Education and Training (FET) band was escalating. The National Certificate Vocational [NC (V)] was introduced at FET colleges from 2007, offering Grade 9 learners the option of a vocational route which exits at NQF level 4. Subsequently, the NMMU considered and defined admission requirements for students wanting to enter higher education (at NQF level 5) via the NC (V). In theory, this was in line with the need to create articulation pathways within and between the academic and vocational learning bands reflected in the South African National Qualifications Framework. However, in practice, potential for increased access, articulation and progression assumes that it is possible to bring qualifications across the vocational-professional-general formative spectrum together into an integrated qualifications structure [3].

In this paper, the articulation and progression between IT vocational/professional qualifications offered by FET colleges and Universities is investigated, using curriculum logic and cognitive complexity as indicators. The specific case of the NC (V) IT and Computer Science as offered by FET Colleges and the Higher Certificate, National Diploma and Bachelor of Technology (BTech) degree in Information Technology as offered by the Nelson Mandela Metropolitan University, is considered.

2. Methodological Framework and Approach

The conceptual and methodological framework applied in this research is discussed in detail in [3]. In summary, the authors propose that the logic of the curriculum (the first indicator used in this paper), can be determined by analysing the module content of a programme according to a knowledge typology as depicted in Figure 1, spanning the range of contextual to conceptual knowledge. With respect to contextually-oriented modules, there are three possibilities: those with procedural knowledge (C1), principled procedural knowledge (C2) and procedural conceptual knowledge (C3). With respect to conceptual-orientation, there are two possibilities: those with predominantly proceduralised conceptual knowledge (applied theory) (C4) and those with predominantly conceptual knowledge (pure theory) (C5).

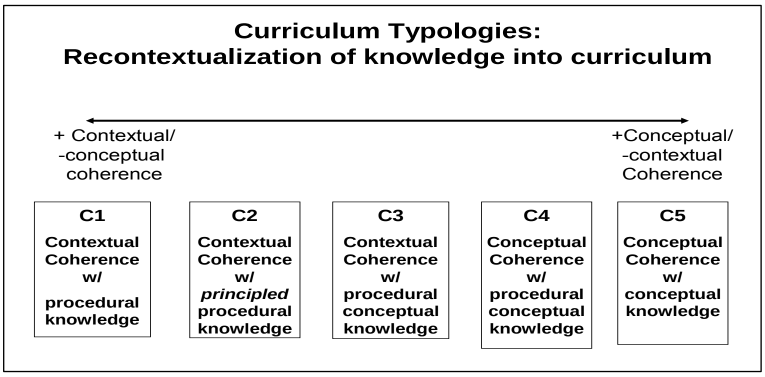

Figure 1. Knowledge typologies.

In order to determine the dominant curriculum logic, the following questions were asked during the analysis of the learning programme modules:

- What is the dominant logic of the module curriculum? Is it predominantly a conceptual or contextual logic?
- What type of knowledge dominates in the module? Is it proceduralised knowledge or principled proceduralised knowledge? Is it conceptual knowledge or proceduralised conceptual knowledge?

What is particularly significant is the distinction between C2 and C3 curriculum types – contextually-oriented modules with procedural knowledge in contrast to those with conceptual knowledge. In other words, the framework recognises the possibility of vocationally-oriented curriculum with a conceptual knowledge base [3].

The second indicator used in this study is cognitive complexity. The levels of cognitive complexity or demand were measured according to the guidelines in Table 1 (as detailed in [3]).

The analysis of cognitive complexity enabled distinction between, for example, a conceptually oriented module which simply required recall (low cognitive demand), explanation (medium cognitive demand) or application (high cognitive demand). The key issue here, as explained in [3], is that cognitive complexity is not coterminous with curriculum type. For example, it is possible to have C3 curricula at a high level of cognitive demand and C5 curricula at a low level of cognitive demand.

In this study, each module that formed part of the research was analysed and coded according to the knowledge typologies (C1 – C5) and levels of cognitive complexity (Low, Medium, High). This analysis was done by an independent researcher (not associated with the IT programmes) and then discussed and confirmed with the lecturers teaching the modules and / or Head of Department. The data was aggregated to quantify the percentage curriculum or logic type and most dominant level of cognitive demand per study year. The results were interpreted to determine the implications on progression and articulation between the academic programmes that formed part of the sample.

Table 1. Levels of cognitive demand / complexity.

Category	Level	Descriptions
LOW Factual Recall / Rote	1: Simple	Simple factual recall.
	2: Medium	Recall complex content.
MEDIUM Understanding of concept / principle; application; analysis	1: Simple	Simple relationships; simple explanations.
	2: Medium	More complex relationships or explanations; counter-intuitive relationships; qualitative proportional reasoning.
	3: Challenging	Identify principles, which apply in a novel context.
HIGH Problem-solving; Creativity / critical & analytical skills / application & integration of all skills	1: Simple	Simple procedure; plug into formula with only one unknown; no extraneous information; known or practised content.
	2: Medium	More complex procedure; construction or interpretation of diagrams; problems with 2 or more steps; basic logic leaps; proportional reasoning; interpretation of data tables; higher level of writing skills / creativity.
	3: Challenging	Integration of all skills; publishable product; complex abstract representation; combination of concepts across sub-fields; complex problems involving insight and logic leaps; formulating new equations (using all unknowns); problem-solving in a novel context.

3. IT Programme Curricula

In this section an overview of the curricula of the various IT programmes considered in this study, are provided. Four academic programmes were analysed as summarised in Table 2.

Table 2. Summary of IT programmes considered as part of this study.

Learning Programme	NQF Levels	Duration	Credits	Band
• NC (V) IT and Computer Science	2, 3, 4	3 years	390	Further Education and Training (FET)
• Higher Certificate IT (User Support Services)	5	1 year	120	Higher Education and Training (HET)
• National Diploma IT (Support Services)	5, 6	3 years	360	Higher Education and Training (HET)
• Bachelor of Technology IT (Communication Networks)	7	1 year	120	Higher Education and Training (HET)

As shown in Table 2, the National Certificate (Vocational) IT and Computer Science is offered over three years at NQF levels 2, 3 and 4. More detail about this programme is shown in Table 3. It should be noted that there are variations to the curriculum – the curriculum shown in Table 3 was used for this study. The programme per year of study is comprised in broad of 3 compulsory fundamental modules totaling 50 credits (Languages, Mathematics and Life Orientation) and 4 vocational modules of 20 credits each. The modules of the NC (V) IT and Computer Science that were investigated as part of this study, are indicated in **bold type** in Table 3.

Table 3. National Certificate (Vocational) IT and Computer Science Curriculum.

	NQF Level 2 (Year 1)	NQF Level 3 (Year 2)	NQF Level 4 (Year 3)
Fundamental Modules	Language Mathematics Life Orientation	Language Mathematics Life Orientation	Language Mathematics Life Orientation
Vocational Modules	Contact Centre Introduction to Information Systems **Electronics** **Introduction to Systems Development**	Contact Centre Systems Analysis and Design **Computer Hardware and Software** **Principles of Computer Programming**	Contact Centre Systems Analysis and Design **Communication and Networking** **Computer Programming**

All the modules of the programmes in the Higher Education and Training band were investigated for this study. In the interest of brevity, these modules are not depicted individually but rather summarised in Table 4 in terms of the primary purpose, knowledge and /or skills emphasis and graduate output profile of each academic programme.

Table 4. Summary of IT programmes in the Higher Education and Training Band.

Higher Certificate IT (User Support Services) Exit: NQF level 5	National Diploma IT (Support Services) Exit: NQF level 6	Bachelor of Technology IT (Communication Networks) Exit: NQF level 7
Primarily vocational / industry-oriented	Primarily vocational / industry / career specific	Primarily professional
Provides basic introductory knowledge, cognitive & conceptual tools & practical techniques for further studies in a chosen field of study	Develops graduates who can demonstrate focused knowledge & skills in a particular field	Provides well-rounded, broad education that equips graduates with the knowledge base, theory & methodology of disciplines
Knowledge emphasises general principles & application & competence in a particular field or occupation	Knowledge emphasises application of general principles	Knowledge emphasises applied theory
Graduate is capable of applying knowledge & competence in an occupation / workplace role	Graduates enter a career path & apply their learning to particular employment context	Principles & theory are emphasised as a basis for entry into the labour market, professional training, postgraduate studies, or professional practice in a range of careers
Includes simulated work experience (WIL) component	Vocational Diploma Includes simulated work experience (WIL) component	Includes an applied project or research project component

4. Results

In this section the results of the coding of the learning programmes according to knowledge typologies (as depicted in Figure 1) and levels of cognitive complexity (as shown in Table 1) are presented in sub-sections 4.1 and 4.2 respectively. A summary of findings follows in sub-section 4.3.

4.1. Knowledge Types

To reiterate, each module of the learning programmes was analysed and coded using the following:
C1 - procedural knowledge
C2 - principled procedural knowledge
C3 - procedural conceptual knowledge
C4 - proceduralised conceptual knowledge (applied theory)
C5 - conceptual knowledge (pure theory)

One example each from the Higher Certificate and National Diploma is shown in Tables 5 and 6 respectively. The result of the coding is shown under the heading **Conclusion** at the bottom right of the tables.

Table 5. Example of Knowledge Type Analysis.
Module: Information Technology Skills (30 credits) from Higher Certificate IT (User Support Services).

Data from …	Examples	Analysis: what is the logic of the curriculum (C1 – C5)? What kind of knowledge?
Learning outcomes / module outlines	• Ability to demonstrate appropriate choices as to conduct, language and sensitivity to user needs. • Ability to apply basic conflict resolution and stress management principles.	**Curriculum logic:** Contextual coherence **Kind of knowledge:** Procedural: Students apply principles of effective communication within the IT context to end-users. **Basic organising logic of the curriculum:** Skills, practices & procedures of effective communication within an IT context; application of IT communication principles to practical situations. **<u>Conclusion</u>** **C2** **Principled procedural knowledge**
Assessment	• Describe five characteristics that the interviewers will be searching for in a future employee? • Identify 5 communication skills that can be implemented together with active listening in order to ensure effective communication. Motivate the role that each skill plays in the communication process.	

In Table 5 it can be seen that the primary curriculum logic of the module *Information Technology Skills* is contextual (rather than conceptual). The kind of knowledge was found to be principled procedural, leading to a categorisation or coding of C2. A similar analysis (with different outcome of C3) is shown for the module *Development Software I* in Table 6.

Table 6. Example of Knowledge Type Analysis.
Module: Development Software I (30 credits) from National Diploma IT (Support Services).

Data from …	Examples	Analysis: what is the logic of the curriculum (C1 – C5)? What kind of knowledge?
Learning outcomes / module outlines	• Explain and demonstrate guidelines for good programming. • Describe and illustrate the use of the Software Development Life Cycle (SDLC), its phases and their application to real situations. • Explain all terminology related to Abstract Data Types (ADTs) and demonstrate, through coding, the different aspects of ADTs.	**Curriculum logic:** Contextual coherence **Kind of knowledge:** Conceptual: students integrate software programming principles extrapolated from the mathematical sciences. **Basic organising logic of the curriculum:** Conceptual knowledge strongly leaning towards application in practical situations. **<u>Conclusion:</u>** **C3: Proceduralised conceptual knowledge**.
• Assessment	• Write a console application that would allow capturing of course attendance details. Generate a report that includes all of the course attendance data for all the streams & indicate the stream (or streams)	

Data from …	Examples	Analysis: what is the logic of the curriculum (C1 – C5)? What kind of knowledge?
	with the highest percentage course attendance.	

The overall outcome of the coding of all the modules in terms of knowledge types (or curriculum logic) is shown in Figure 2. The overall curriculum logic of the four programmes is contextual with a dominance of **C2** (principled procedural knowledge) in most years. This is shown in Figure 2 using light blue shading. The dark blue shading shows that Year 1 and Year 2 of the National Diploma have a 25% and 50% emphasis on procedural conceptual knowledge (**C3**) respectively. The overall dominance in C2 curriculum logic implies that based on this indicator only, progression should not be problematics from the National Certificate (Vocational), to the Higher Certificate, National Diploma and Bachelor of Technology in the case of the programmes analysed in this research.

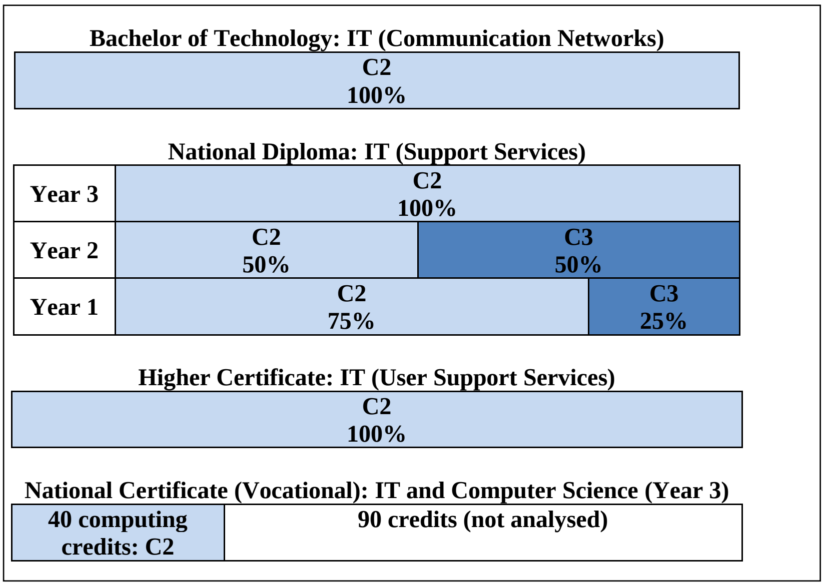

Figure 2. Knowledge types / curriculum logic, NQF levels 4 - 7.

4.2. Cognitive Complexity

The overall outcome of the coding of all the modules in terms of cognitive complexity is shown in Figure 3. The analysis shows a consistent increase in cognitive complexity from the National Certificate (Vocational) up to the Bachelor of Technology degree. This is shown in Figure 3 using yellow shading for low cognitive complexity, orange shading for medium cognitive complexity and red shading for high cognitive complexity. The consistent increase in cognitive complexity from the NC (V) to the Bachelor of Technology, implies that based on the indicator of cognitive complexity only, progression should not be problematic from the National Certificate (Vocational), to the Higher Certificate, National Diploma and Bachelor of Technology in the case of the programmes analysed in this research.

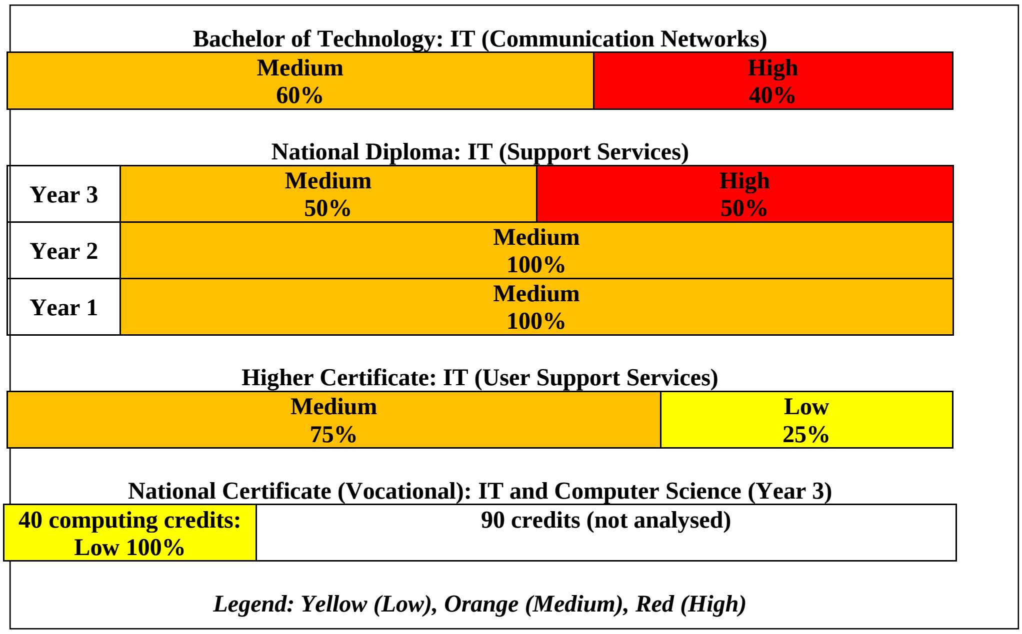

Figure 3. Cognitive complexity, NQF levels 4 - 7.

4.3. Summary of Findings

In sub-sections 4.1 and 4.2 it was concluded that progression should not be problematic from the National Certificate (Vocational), to the Higher Certificate, National Diploma and Bachelor of Technology in the case of the programmes analysed in this research. This was based on the individual consideration of the indicators of curriculum logic and cognitive complexity. Notably, progression from one learning programme to the next requires increasing cognitive complexity, specifically in the dominant curriculum type. Thus Figure 4 presents a combined matrix of the indicators of knowledge type and cognitive complexity as applied in this research.

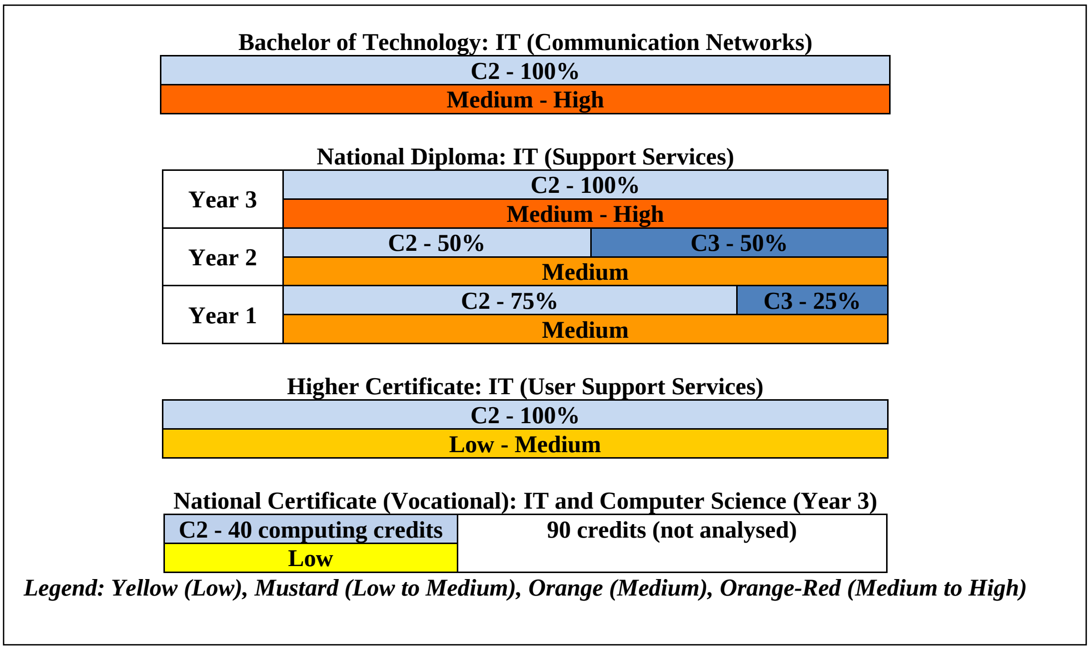

Figure 4. Matrix of indicators.

In Figure 4, the depiction of the curriculum logic of the four learning programmes is shown similar to Figure 2, using light and dark blue shading. The indicator of cognitive complexity is depicted differently than in Figure 3 though, with the intent to show clearly the increase in cognitive complexity **within** a particular learning programme and also **between** two learning programmes. Yellow shading is used for low cognitive complexity, mustard shading for low-to-medium cognitive complexity, orange shading for medium cognitive complexity and orange-red shading for medium-to-high cognitive complexity.

The combination of the indicators in one diagram shows increasing cognitive complexity in the dominant knowledge or curriculum type, **between** all four the programmes. It also shows, however, that there is no increasing cognitive complexity **within** the NC (V) learning programme. Increasing cognitive complexity measures satisfactorily **within** the other three learning programmes. For example, an increase in cognitive complexity from low-to-medium is evident in the Higher Certificate learning programme.

Based on the afore-mentioned findings, the implications for progression and articulation between the four learning programmes are summarised in Table 7.

Table 7. Implications for progression and articulation.

	National Certificate (Vocational) IT and Computer Science	**Higher Certificate IT (User Support Services)**	**National Diploma IT (Support Services)**	**Bachelor of Technology (Communication Networks)**
Dominant logic	C2 Core	C2 Core	C2 & C3 core	C2 core
Complexity	No increase in cognitive complexity	Increase in cognitive complexity	Increase in cognitive complexity	Increase in cognitive complexity
Progression and articulation	Progression to Higher Certificate could be problematic	Progression to National Diploma unproblematic	Progression to BTech unproblematic	Progression from Bachelor of Technology to NQF level 8 not analysed, but could be problematic assuming that some conceptual coherence (C4) is required.

Based on the fact that there is no increase in cognitive complexity within the National Certificate (Vocational), it is concluded that progression from this Certificate to the Higher Certificate (**between** the Further Education and Training and Higher Education and Training bands) could be problematic. However, progression from the Higher Certificate to the National Diploma and from the Diploma to the Bachelor of Technology, is not seen as problematic. Progression from the Bachelor of Technology to NQF level 8 was not investigated. It is ventured that it could be problematic, assuming that some conceptual coherence (C4) is required at that level.

5. Conclusion

This paper investigated progression and articulation between vocational and professional IT qualifications, using curriculum logic and cognitive complexity as indicators. The curricula of four learning programmes were analysed, viz. the National Certificate (Vocational) IT and Computer Science offered by FET colleges, and the Higher Certificate, National Diploma and Bachelor of Technology degree in Information Technology as offered by the Nelson Mandela Metropolitan University. The results offer useful information about progression and articulation between these learning programmes.

The study demonstrates the utility of the framework that was applied in the execution of the research. The framework provides a principled basis and academic rationale for curriculum differentiation and can assist in the (theoretical) assessment of progression and articulation between learning programmes. This can assist to design viable articulation and progression pathways within and across the academic and vocational learning bands reflected in the South African National Qualifications Framework. Such pathways will bring to fruition the integrated nature of the qualifications framework, offering access to a wider diversity of students, but designed in a manner to support the potential of success.

6. Acknowledgements

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Agential independence and interdependence in the workplace: preparing students for vocational internships

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Abstract

This pilot study interrogates the notion of human agency. The dimensions of agential independence and interdependence and their relationship to the performance of graduates in the workplace are explored. A model representing the latest conceptions around innovation in the SME and enterprise sectors in the business environment is developed. The model is then used in conjunction with the Indepedent-Interdepedent Problem-Solving Scale (IIPSS) to explore an optimum placement strategy for students on the basis of their IIPSS index.

Keywords: *human agency; agential independence; agential interdependence; entrepreneurship; intrapreneurship; vocational internships*

1. Introduction

1.1 Background and Objective

The Cape Peninsula University of Technology (CPUT) offers a range of formal and non-formal professional and vocational courses. Internship placement is an important and integral aspect of the curriculum and is regarded as being crucial to the career development of students. Students are placed in various industries, including the enterprise sector and the small business environment. CPUT achieves high placement rates for our graduates and has maintained robust long-term relationships with industry partners to support our internship programmes. The continuous pursuit to achieve alignment of exit level outcomes with evolving industry requirements is key to sustaining the success of these relationships [1] [2] and ultimately ensures the successful placement of our graduates in industry.

This study is part of ongoing research conducted in support of the CPUT Information Technology (IT) programme and our research focus is therefore on students of the formal and non formal IT programme and limited to internship partners in the Information and Communications Technology (ICT) enterprise and SME sectors. Our findings are shared here with the intention of making our research available to the wider tertiary education community, to invite collaboration and to stimulate further research.

1.2 Aim of the Study

The Problem. Industry requirements in the fast-paced information economy are continuously evolving. This presents a challenging problem for universities of technology. They must keep pace with these changes if they are to achieve alignment of higher education outcomes in industry needs and thereby remain relevant. This is crucial in order to ensure that graduates are adequately equipped with the relevant knowledge, skills and capabilities to perform effectively in the workplace [1] [2].

The Questions. In pursuing the research problem in the context of our study, the following questions need to be addressed. What are the latest innovations in industry that should be considered for integration into the curriculum? What skills and proficiencies need to be considered to ensure that graduates continue to perform effectively in the workplace? What are the similarities and differences in the requirements of the enterprise and SME sectors that could inform our graduate placement strategy? How may graduates be effectively assessed and evaluated to determine optimum placement in different industry environments and to guide remediation?

The Method. Firstly, the contribution of the theory of Human Agency to recent skills research will be reviewed in the literature study. Human Agency (HA) will be positioned within a matrix of skills and proficiencies that are appropriate to the alignment of learning outcomes with industry needs. Following on from this, the aim of this pilot study is to conduct exploratory research into the dimensions of agential independence and interdependence and their relationship to the performance of graduates in different industry environments. Secondly, the latest conceptions around innovation in the business environment will be interrogated to determine the current state of industry requirements. The effective interaction between innovative capability and dimensions of human agency will be explored. To this end, a concept model representing the relationship between entrepreneurship in the small medium enterprise (SME) and enterprise environment and the HA orientation of agential independence and agential interdependence will be developed.

This study furthermore seeks to establish an approach to measure the agential orientation of students with the view of optimizing their placement. The concept model is used in conjunction with the “Indepedent-Interdepedent Problem-Solving Scale” or IIPSS of Rubin et al [3] to establish an optimum placement strategy for either the SME or enterprise environments. The efficacy of the IIPSS as a tool to guide the placement of students to the particular industry type on the basis of their IIPSS index is assessed.

2. Literature Study

A wide variety of studies, Information Systems Association reports, government and e-skills consortia reports have assessed ICT industry requirements both in South Africa and internationally and have developed typographies and rankings of skills and proficiencies that are appropriate to current industry needs. In doing so, they have identified ICT core technical knowledge and skills, business expertise, soft skills and personal attributes (such as interpersonal abilities, communication and team skills, creative and critical thinking skills) as of importance [1] [4]-[7].

A number of recent studies have emphasised the significance of personal attributes as critical success factors and have stressed the need for further research [1] [8]. The skills matrix and ranking from McMurtrey et al [2]
Table 1 here following is a good representative example of this. It is notable that the matrix coheres significantly with the IS 2010: Curriculum Guidelines for Undergraduate Degree Programs in Information Systems. [5]

Table 1. Top Twelve Skills
McMurtrey et al [2]

Rank	Skill	Area	Mean	t-value *	Sig. more imp. than
1	Problem Solving	Personal Attributes	6.69	4.24	Oral Comm.
2	Critical Thinking	Personal Attributes	6.59	3.30	Oral Comm.
3	Team Skills	Personal Attributes	6.52	2.64	Oral Comm.
4	Oral Comm.	Personal Attributes	6.22	5.69	Ethics/Privacy
5	Creative Thinking	Personal Attributes	6.18	5.34	Ethics/Privacy
6	Written Comm.	Personal Attributes	6.07	4.51	Ethics/Privacy
7	Ethics/Privacy	Business Expertise	5.46	3.25	C-S Databases
8	Database (2 items)	IS Core Knowledge	5.24	1.97	Languages
9	C-S Databases	Proficiency	4.98	N/A	N/A
10	Languages (4 items)	IS Core Knowledge	4.96	N/A	N/A
11	Security	Business Expertise	4.93	N/A	N/A
12	Object-Oriented	IS Core Knowledge	4.80	N/A	N/A

*Significant at $p < .05$. For significance, the *t*-value must be greater than 1.96

While the preceding studies highlight the importance of personal attributes and identify the importance of personal and cognitive skills, they lack the inclusion of the critical success factors that drive performance. They address capability and competence but not the essential elements of motivation and efficacy. We have subsequently striven to find an analytic context in which to structure our exploration in this area.

As a driving concern of our research is to determine the factors that could optimize the efficacy and performance of graduates, we have turned to Social Cognitive Theory and the attendant Theory of Human Agency to explore the means by which technical, business, inter-personal and cognitive skills are sustained and brought effectively into action. As Bandura defines it, human agency encompasses those "self-organizing, proactive, self-reflective and self-regulative mechanisms" that drive self-efficacy [9] - in this sense, HA can be viewed as a 'master skill' being the key to the effective actualization of all others. Of these functions, the core driver of motivation and action is self-reflexivity. The individual is empowered though achieving success in the work or academic environment. By reflecting on this achievement, the individual generates a sustaining self-efficacy belief that becomes a source of motivation and enablement when facing new problems and challenges [9].

The primary aim of this study is to explore the dimensions of agential independence and interdependence and their relationship to the performance of graduates in the workplace. The concept of agential independence (AI) is essentially equivalent to the preceding definition of HA itself. Central to both of these notions is a person's capability to act independently of the environment, to be self-organizing, proactive, self-reflective and self-regulative [9]. In addition AI requires reflexivity and thereby the capacity to abstract oneself from the immediate situation, no matter how challenging, and to be driven by the prior experience of competence [10]. This agential orientation also has an effect on human interaction in the workplace. The agentially independent individual will develop the capacity to rely on themselves to solve problems and achieve their goals. Conversely, AI will correspond with the need to consult others and to rely on them to achieve objectives. This correlation between these qualities of AI and problem solving orientation suggest further that the *Indepedent-Interdepedent Problem-Solving Scale (IIPSS)* of Rubin et al is a viable means of testing agential orientation [3].

It is important to consider the dimensions of HA when matching students to the type of workplace environment in which they are placed as they may have a significant impact on their performance. Accordingly, it has been necessary for our current research objective to review the latest conceptions around innovation in the business environment to optimize student selection for either enterprise or small medium enterprise (SME) positions. Innovation behaviour is closely associated with entrepreneurship and has received significant attention during the last decade. At the same time, the SME sector has been seen as a locus of economic growth and job creation during the protracted period of economic stagnation [11]. The corporate sector has consequently sought to harness the entrepreneurial spirit of autonomous individuals and their ability to discover new products, business opportunities and markets [12].

This confluence of entrepreneurship - the domain of the independent, innovative and effective individual and in essence, a self-organizing, proactive and self-regulative process - with the strategic objectives of corporate strategy provides the point of departure for the development of our conceptual model of agential orientation and business innovation. The characteristics of the entrepreneur correspond closely to those of human agency and an agential independent orientation as previously reviewed. This is most evident in the definition of De Jong & Wennekers [12] who identify the entrepreneurial individual as one who is proactive, having a strong desire for action, an initiator of activities without seeking the approval or permission of others and one whom persists in their entrepreneurial activity notwithstanding the negative reactions of others or their environment. The parallel between the defining characteristics of the entrepreneur and the AI orientation are strikingly evident. The SME or self-owned business is also perceived to be the domain of the entrepreneur, where the independent process may flourish unencumbered [12]. Conversely entrepreneurship in the enterprise sector occurs in an environment where there is a requirement to consult with and be directed by others. The enterprise is seen as the domain of intrapreneurship where initiative originates top down from corporate imperative and the innovative activity is circumscribed by enterprise strategic objectives [13]. The defining characteristics of intrapreneurship would accordingly map to agential interdependence. This would provide a neat solution and outcome for our study. Our student placement selection would accordingly be made on the basis of the agential orientation of students and independent students would be placed in internships in the SME sector and interdependent students sent to enterprise.

The first version of our concept model showing the interrelationship between human agency, entrepreneurial orientation and placement in the enterprise or SME environment is shown in Figure 1 following.

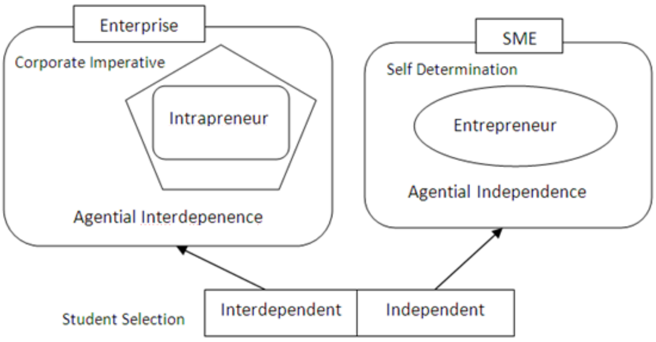


Figure 1. Concept Model I
As developed by the authors

As our focus group revealed and further literature study indicated, the situation is more complex. In the SME environment the individual entrepreneurial process has free rein. However, as a result of limited capacity, skills, knowledge and resources, the business on an operational level is ultimately sustained by establishing interdependent relationships with other SMEs and organizations [14]. Conversely, in the corporate environment, intrapreneurship is only effective if the independent entrepreneurial spirit is allowed to flourish unencumbered. The corporate entrepreneur in the enterprise business development department also enjoys the benefit (and added independence) of having ready access to enterprise intellectual capital and resources from other departments. In addition, not having to be a jack-of-all-trades, the intrapreneur is able to devote undivided attention to creative entrepreneurial activity[13]. What is important to note however is that agential independence is the point of departure, and that it is from this locus at the personal level that interdependent synergistic relationships that sustain the entrepreneur are made at the organizational level – inter-firm in the SME environment and for the intrapreneur, inter-departmental relationships in the enterprise environment [12].

Our concept model has evolved accordingly as illustrated in Figure 2. Concept Model II following.

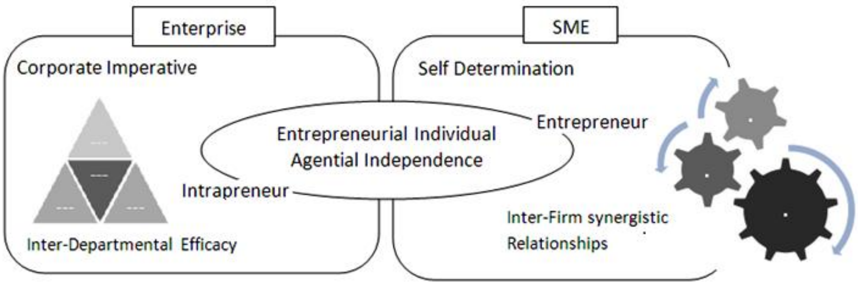


Figure 2. Concept Model II
Developed by the authors. Elements adapted from Åmo & Kolvereid [13]

It is important to clarify the relationship between agential independence and the ability to work in teams as this is an important attribute associated with efficacy in the workplace, particularly in the ICT industry [2] [5]. The self-reliance of the agentially independent individual does not imply that he or she will be lacking in team skills. On the contrary, the proactive and self-regulating qualities of agency make for a valuable team member.

The secondary aim of our ongoing research is to explore the viability of fostering agential orientation through training and mentoring. In the context of this study, this would involve the development of agential independence as a driver of innovative behaviour into a teaching and learning practice. A starting point has been provided by researchers such as Lassig [15] who have conducted rigorous studies of the social and environmental conditions under which creative behaviour may be fostered. In addition, she identified the means by which creative self-efficacy, a core tenet of HA, could be nurtured through reflexive educational practice. This is supported by a significant body of research by writers such as such as Do & Gross [16] as well as Nanda & Sorensen [17] who have looked at the effect of peers in the workplace on the development of innovative and entrepreneurial behaviour. It is beyond the scope of this pilot study to go further into this research. The significant effect of colleagues and mentors in the ICT industry through collaboration and job shadowing is addressed in the discussion of results of the structured interview.

In conclusion, whether they are to enter the SME or corporate domain, the literature study has indicated that students should be selected on the basis of agential independence for optimum graduate placement and efficacy in the workplace in both the corporate and SME environment where the innovative and independent behaviour is effective and highly valued. The research of Rubin et al [3] confirms that the Interdependent-Independent Problem Solving Scale (IIPSS) can be a reliable indicator of independence. Whether it may be successfully used as the basis for selecting CPUT students for optimum placement based on their agential independence orientation is assessed as follows.

3. Methodology

Data collection towards establishing a plausible theoretical model in support of the “agential orientation” conception has been done through literature search. Data collection towards gaining insight into the placement preferences of students was achieved by using the Independent-Interdependent Problem-Solving Scale (IIPSS) quantitative instrument. Exploration of the imperatives for redressing agential orientation through training has been achieved through semi-structured interviews of relevant industry professionals.

3.1 Quantitative Analysis

The Independent-Interdependent Problem-Solving Scale (IIPSS) questionnaire [3] was delivered to 94 students at CPUT in the formal National Diploma IT and non-formal ICT Academy vocational programmes in their first and second year of study. The aim was to establish if the IIPSS was able to reliably determine which of the 94 students fall significantly into either the independent or interdependent group and thus determine their agential orientation. This would indicate if they were ready for industry internship or if they required further preparation prior to their internship placement.

The students answered a set of ten questions, five indicating independence and the other five dependence such as: “In general, I do not like to ask other people to help me to solve problems” or “I do not like to depend on other people to help me to solve my problems” vs “I usually prefer to ask other people for help rather than to try to solve problems on my own”. The questions were scored on a 7 point Likert-like scale ranging from 1 “Strongly Disagree” to 7 “Strongly Agree”, the median response being 4 “Neutral” [3].

The participants’ responses to the independent problem-solving items were reverse coded and then the average score of all 10 questions computed so that independent problem-solving achieved a low score and interdependent problem-solving a high score.

3.1.1 Reliability

Cronbach’s alpha indicated a questionable result for the interdependent group and poor result for the independent group. Possible reasons for this are discussed in the results section following. As the ultimate outcome of the survey resulted in a productive qualitative analysis, this measure of internal consistency is not of significant concern and is given here following in Table 2. for completeness.

Table 2. Reliability Statistics

Points	Cronbach's Alpha	N of Items
Independent Group	.518	5
Interdependent group	.643	5

3.1.2 Results

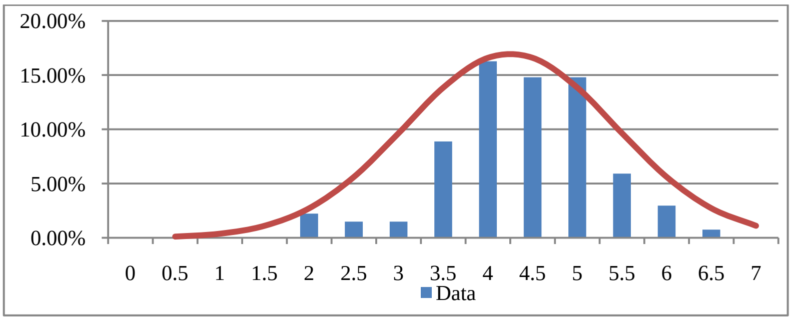
Following the procedure used by Rubin et al in the pilot test of the IIPSS [3], respondents would be grouped as independent problem solvers if their scores were lower than the mean of the scores minus 1 standard deviation and as interdependent problem solvers with scores higher than the mean of the scores plus 1 standard deviation. Assuming a normal distribution this would by default exclude 68% of the participants and of the remainder, 16% would be independent problem-solvers and 16% would be interdependent problem-solvers.

We conducted an exploratory analysis of the data on this basis. The results were more extreme than anticipated. Only 10 students (10.6 % of the students) could be classified as Independent Problem Solvers and 13 students (13.8% of the students) could be classified as Interdependent Problem Solvers and 75.5% of our students were unable to be classified in either of the groups. The results are illustrated in Table 3 following.

Table 3. Categorical Analysis of Results

Points	Frequency	Percent	Valid Percent
Neutral Range Score	71	75.5	75.5
Independent Group	10	10.6	10.6
Interdependent group	13	13.8	13.8
Total	94	100.0	100.0

The analysis revealed significant kurtosis in the distribution, the majority of the values being in the peak and less than would normally be expected in the tails. These results were instructive as this indicated that a higher than expected proportion of the students tended towards the median score (responding in the range of partially agree-neutral-partially disagree range of the scale with cut off at 3.2 and 5 respectively) and were significantly neither independent nor interdependent problem solvers. This is given here as a graphical illustration in Figure 3 following.



Low scores Independent, Median 4 Neutral, high scores Interdependent

Figure3. Descriptive Analysis of Results and Normal Curve

3.1.3. Discussion of Results

From the standpoint of a categorical analysis, the IIPSS does not advance our strategic objective of selecting students on the basis of AI for optimum student internship placement in either SME or Enterprise workplace environments. Were we to proceed on this basis, our placement rate would be

10.3% and 89.7% of the students would remain on campus in the Simulated Industry Exposure programme for remedial intervention when our present profile is the inverse of this.

The results were submitted to Mark Rubin, a co-author of the IIPSS for comment [3]. He identified the kurtosis in the distribution of the results mentioned previously, and recommended that the IIPSS score be used as a continuous variable rather than as categorical indication of group membership and that the data should be analysed instead as a correlation between the IIPSS score and preparedness for internship placement. The adoption of this approach enables the assessment instrument to reveal significant, useful insights that advance our original exploratory research objective.

The literature study brought us to the conclusion that agential independence is the key characteristic to be identified and developed for optimum industry placement. In addition AI is also leveraged to achieve success in important interdependent relationships at the inter-firm level in the SME and inter-departmental efficacy in the corporate sphere. Accordingly, independent and interdependent agential orientations may be viewed as complimentary rather than mutually exclusive. If the results of our IIPSS survey were viewed in this light, it would indicate that both our independent and interdependent tending individuals have achieved part of the objective and require the development of the counter capability. The independent group however have an advantage, as agential independence can be leveraged to pursue interdependent relationships at another level. As revealed by the focus group, mentoring relationships can also result in growing confidence and independence.

The large middle field provides a fertile ground for further research questions. It may be the case that majority have already arrived at our current understanding and are not in two minds about certain of the questions. Perhaps when considering the question “I prefer to make decisions on my own, rather than with other people” and “I value other people’s help and advice when making important decisions” they do not find the two mutually exclusive. The agentially independent, self-reflexive individual having attempted to solve a problem themselves but not having succeeded, now actively seeks and evaluates advice in order to reach an informed decision. Whether the students in the 75.5% middle range lack or possess both agential characteristics and require engagement to distinguish and develop them, are compelling questions to be addressed in future research.

3.2 Focus Group Interview

A focus group interview was held with four ICT professionals with between 15 to 30 years of experience, representing a cross section of the industry. The group was comprised of: a consultant and ex CEO of a national tertiary education and research network; a corporate client account manager who worked in two of South Africa’s leading internet service providers; a business owner of an SME Network Infrastructure Solutions Provider and consulting firm which outsources expert engineers to enterprise clients; and a certified internet expert engineer with extensive experience of working in corporate networks and ISPs. The session was recorded and transcribed in note form.

The nature of the research project was described to them as an initiative to identify industry requirements to assess students prior to placement in industry internship programmes and adequately prepare them for optimum performance in the workplace.

Three questions were put to them.

a. What are the qualities that you look for that would ensure the successful placement of an IT graduate in your internship programme and ultimately employment?

b. Which of the qualities of independence or interdependence do you value more in a prospective employee or are both equally important in areas like problem solving and achieving goals?

c. Considering your answers to 1 and 2, do you think these qualities can be developed through training / mentoring / experience?

3.2.1 Results

CEO

The CEO advised that the assessment should take place as an entrance test at the commencement of university education so that remediation was part of the university education. He felt that this could be achieved by assigning the student to a mentor to build the confidence of the student.

Corporate Client Account Manager

The account manager valued maturity, emotional intelligence, interpersonal skills and the ability to communicate in a professional manner and remain calm under stressful conditions. He particularly looked for an individual who could understand their role as part of a delivery chain and who possessed team and client skills.

SME Director / Consultant

The Director held that the engineering skills of an incumbent engineer are far less important than personal attributes which were the most important characteristic he looked for in a prospective engineer – he said it was relatively easy to pass an entry level network engineer certification but that what really counted in his opinion was the personality of the individual. He cited ability to prepare and plan for a client project, understanding of the implications of being responsible for a client's network (and the trust relationship that this involved) and personal accountability as critical factors.

He also considered independence was to be paramount as well as the ability to solve problems and conduct research on own initiative. This was a key characteristic that he looked for when hiring an engineer. He added that the ability to develop and sustain effective support relationships provides an enormous stimulus for growth. He felt that interdependence creates value when the successful combination of the different skills and abilities of the individual members are necessary for the success of the venture. He added the proviso that as an integral part of the whole, if the individual is not capable in their own right the venture fails.

Expert Engineer

The expert engineer viewed the career progression from novice to expert as a development path from interdependence to independence. In his work he performs the role of mentor when allowing junior engineers to job shadow him. Yet he felt that as an expert engineer, one still found benefit in synergistic relationships.

3.2.2 Discussion

The contribution of the CEO to the interview revealed that an interdependent mentoring relationship can build independence during the formative process. This was confirmed by the expert engineer who conducted these relationships. The CEO confirmed that independence should be an exit level outcome and should be achieved by the educational system prior to placement.

The Director was of the opinion that personal attributes are of the highest significance. Of these, human agency which he described as being proactive, having self-regulation and being prepared for the job was paramount. In addition, an understanding of accountability and possessing awareness of their role in a client trust relationship was critical. This was in accordance with the hypothesis that independence is a key characteristic, is prior to interdependence, and is related to problem solving ability. Originating from a starting point of independence, the value creation possibilities of interdependent synergistic relationships was confirmed and the contribution of this interviewee accorded with the second iteration of our concept model.

4. Conclusion

The literature study revealed that the theory of Human Agency has a valuable contribution to make to current skills education and industry alignment research. Recent studies that rank key capabilities in a sequence from technical knowledge to personal and cognitive attributes omit the drivers of performance in the workplace. Human agency is the engine of self-efficacy and can be seen as a 'master skill' that achieves the actualisation of all the others.

The development of the model that mapped the dimensions of agential independence and interdependence and their relationship to the conceptions of entrepreneurship and intrapreneurship in enterprise and SME environments successfully guided and evolved our strategy for optimum graduate placement. Our initial tendency was to identify agential interdependence as a defining success factor in the enterprise domain where corporate strategy is the source of direction as opposed to independence as the success factor in the SME environment where self-determination is the driving process. Ultimately, further exploration revealed that without agential independence existing freely in both environments, the essence of innovation is extinguished. Furthermore, without the sustenance of interdependent relationships at the organisational level, the longevity of the process could not be assured either. As it was determined that independence was the core attribute, students could be placed on the basis of their IIPSS index for independent orientation in both environments.

The focus group session provided significant corroboration of this complementary nature of agential orientation and the viability of expanding the interview process in future research.

The study was a pilot study and while the quantitative research process did not achieve our goal of selecting students for optimum industry placement, the interrogation of the results yielded significant and viable insights and achieved our research objective to advance our theory and guide further research. As an insignificant number of respondents fell into the independent or interdependent categories, it made more sense to analyse the data as a correlation and trend analysis. From this perspective the data confirms the insights of our literature study. As the development of our conceptual model revealed, both agential interdependent and independent capabilities were necessary for performance in the SME and enterprise environments but in combination, not in isolation. Accordingly, those with high or low IIPSS scores would benefit from the development of the complementary capability to prepare them for internship. Whether the majority in the middle range lack or possess both agential characteristics are compelling questions to be addressed in future research.

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Applying modeling and simulation techniques to characterize an infrared heater

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Abstract

The purpose of this paper is to present a theoretical investigation of the behaviour of an infrared (IR) heater during heating and cooling stages. A method for the application of modelling and simulation techniques using popular engineering software programs is presented. A mathematical model is developed for transient and steady state conditions in order to characterise an infrared heater. The equations were solved using tools such as MATLAB, Simulink and LabVIEW. The model presented on this paper provides a thermal simulation and optimization of the design characteristics of an infrared heater. The paper includes non-grey radiative heat transfer between different parts of IR heater, as well as conduction and radiation. The geometry has been simplified into a one dimension problem.

Keywords: *Infrared heater, mathematical model, heat transfer.*

1. Introduction

For centuries infrared technology has been used in various domains and industries and continues to develop every day and its discovery has led up to revolutionary techniques.

Infrared heaters are mostly used in the zone control of food handling and processing [1], and on fruit heating and drying applications [2]. It is also utilised in paddy drying process [3], vacuum dryer [4] and rice [5].

The present paper discusses the modelling, heating and cooling stages of an IR heater. A model of a IR heater has been developed and the effect of its parameters such as the filament wire, the ceramic reflector, the distance between the heater and surface have been studied.

2. Principles of Infrared Heating

Infrared rays are classed according to their position on the electromagnetic spectrum and their radiations are organised by wavelength or frequency. All electromagnetic waves obey to the general equation:

$$\lambda v = c \tag{1}$$

Where c is the velocity of light, v the frequency and λ is the wavelength. All electromagnetic waves propagate at the velocity of light but are different in frequency and wavelength from one another.

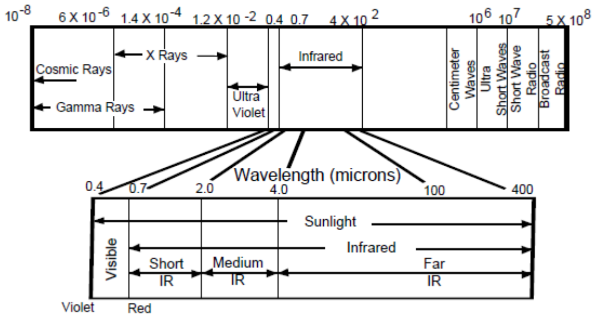

Figure 1: Electromagnetic wave spectrum [**6**]

The thermal radiation is the rate that energy is transferred from a surface to another by means of electromagnetic waves. Thermal radiation does not require the use of a medium between elements. It is also proportional to the difference of temperature to the fourth power:

$$q \propto ({T^4}_1 - {T^4}_2) \tag{2}$$

IR radiation can be classified into three ranges such as, near-infrared (NIR), mid-infrared (MIR) and far-infrared (FIR).

Table 1. Subdivision of infrared on electromagnetic spectrum

Designation	Abbreviation	Limits, µMicrons (µm)
Near Infrared	NIR	0.76 to 2
Middle Infrared	MIR	2 to 4
Far Infrared	FIR	4 to 100

When heat is transferred to a surface by electromagnetic radiation, incident radiation may be absorbed, transmitted or reflected as shown below:

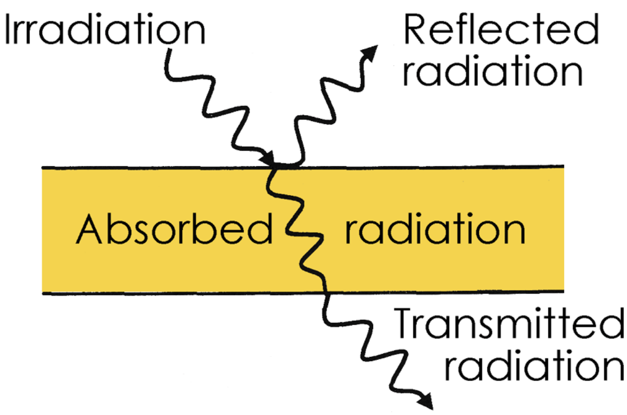

Figure 2: Extinction of radiation (absorption, transmission and reflection of radiation) [**7**].

All heaters obey to the following laws for a blackbody radiation:

- **The Stefan-Boltzmann law** states that as the temperature of a body increases

$$E_b = \sigma T^4 \tag{3}$$

- Planck's law

The heat transfer emitted by radiation or the missive power from a blackbody is:

$$E_{\lambda,b}(\lambda, T) = \frac{C_1}{\lambda^5 (e^{C_2/\lambda T} - 1)} \tag{4}$$

- Wien's displacement law

Wien's displacement law is the wavelength at which the emissive power $E_{\lambda,b}$is maximum.

$$\lambda_{max}T = 2897.8\ \mu m. K \qquad (5)$$

3. Infrared heaters

IR heaters, also called infrared radiant heaters as referred to the sun, operate in a similar way that the sun does. Application of heaters may vary from drying, heating in food industry or for household applications, to boiling, furnace application for commercial building **[**8**]**.

IR ceramic heaters are designed with coiled heating element wire such as iron, chrome and aluminium with high emissivity. The wire is embedded inside the ceramic materials in such a way that it becomes resistant to thermal cracking. The whole system is conceived to prevent any damage and oxidation and corrosion **[**9**]**. IR heaters are energy efficient with efficiency of about 95% and can radiate from medium-wave to long-wave spectrum. It is found in the literature **[**9**]** that peak values of radiation vary between 3.3 and 5.7 μm.
The filament wire used for simulation is a Nickel Chromium alloy coil element (Nikrothal 80) from Kanthal Industry which has a good workability and can operate at high temperatures up to 1200 °C. It has a spiral form with dimension of 0.3mm diameter and 4m long respectively; the wire is flexible and can be embedded into ceramic clay. It is characterised with a high resistivity, a good oxidation resistance and stability.

4. Mathematical model

A schematic was developed. The radiation heat transfer is described similarly to the one suggested by Pettersson and Strenstrom **[**10**]** with assumptions that radiation is to be diffuse and the model for radiation exchange will have to be non-grey for simplification purpose. The geometry of IR heater is shown in Figure 3. A symbol is allocated on each surface with regards to the radiosity *Ji*, and irradiation Gi.

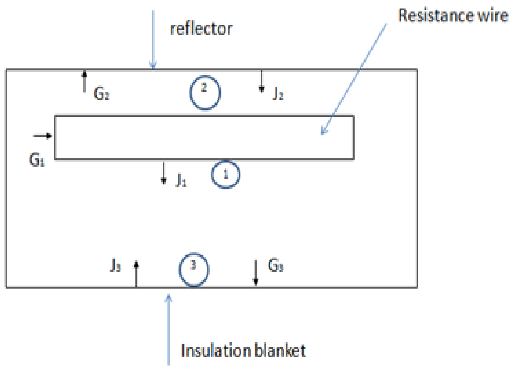

Figure 3: Schematic of FIR heater

4.1Radiation exchange

The Planck's law for blackbody is specified in Eq. (6) to evaluate the emitted blackbody power $E\lambda$ as well as radiation balances within a given wavelength interval.

$$E\lambda = \int_{\lambda_2}^{\lambda_1} \frac{2\pi h C_0^2}{\lambda^5\left[e^{hC_0/\lambda kT}-1\right]} d\lambda \qquad (6)$$

The radiosities according to Figure 3. are expressed for each surface in Eq. (7), (8), (9). The heater surroundings are considered to be black.

$$J_{\lambda,1} = r_{\lambda,1}G_{\lambda,1} + \varepsilon_{\lambda,1}E_{\lambda,1}$$

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$$J_{\lambda,2} = r_{\lambda,2}G_{\lambda,2} + \varepsilon_{\lambda,2}E_{\lambda,2} \qquad (7)$$

$$J_{\lambda,3} = \varepsilon_{\lambda,3} E_{\lambda,3} \quad (8)$$

4.2 Energy balances

- **Heating rate**

Due to the passage of an electrical current *(I)*, the filament initially in thermal equilibrium will oppose a resistance. The variation of the filament temperature is equal to the power lost by the filament through convection and radiation. Steady state is reached when the current passing through that filament has become constant. The variation of the filament temperature during the passage of current is given by Eq (10).

$$m_f C_{pf} \frac{dT}{dt} = P - Q_{conv} - Q_{rad} \quad (9)$$

$$P = \frac{U^2}{Re_f} \quad (10)$$

This variation of temperature can be expressed with the volume of the filament, the electrical resistance and natural convection and radiation heat transfers. It is given by the following equation:

$$\frac{dT}{dt} = \frac{1}{\rho V C_p}\left[\frac{U^2}{Re_f} - h_{conv}A(T - T_\infty) - \varepsilon\sigma A(T^4 - T_{sur}^4)\right] \quad (11)$$

The above equation is a first order differential equation, and was computed in MATLAB as well as LabVIEW using the Fourth-order Runge Kutta method for Ordinary Differential Equation (ODE 45). The Simulink model as well as LabVIEW front panel and block diagram representing the rate of temperature change for this equation are shown in Figures 4.

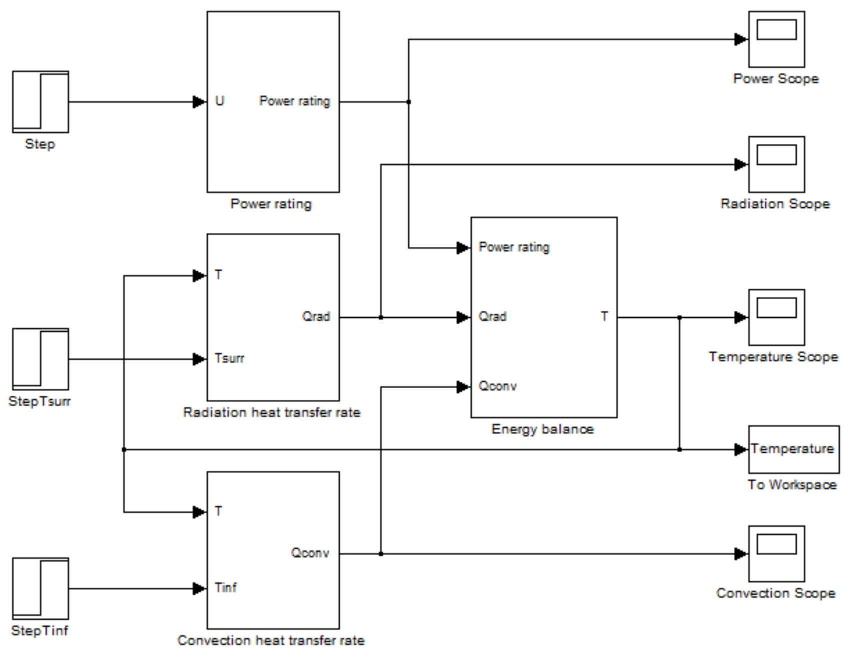

Figure 4: Simulink model of change of temperature in filament.

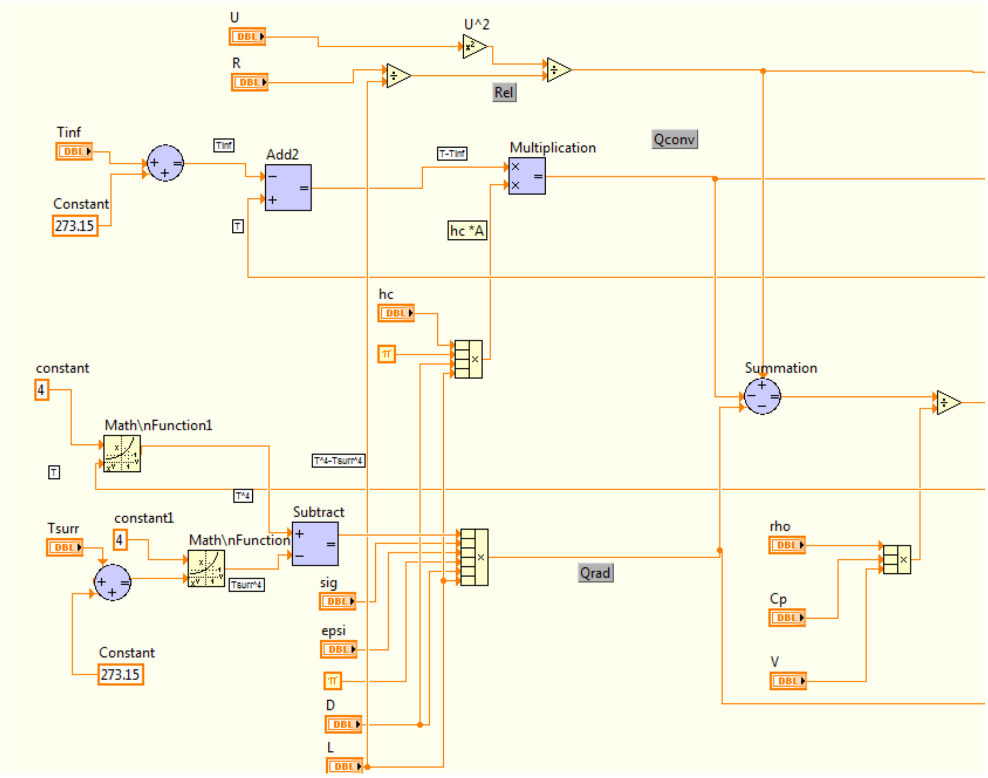

Figure 5: LaBVIEW block diagram representing heating stage

Steady state is reached when $\frac{dT}{dt} = 0$. Eq. (11) becomes:

$$\frac{U^2}{Re_f} = h_{conv}A(T - T_\infty) + \varepsilon\sigma A(T^4 - T_{sur}^4) \qquad (12)$$

- **Cooling down:**

The cooling down is observed when the heater is off. The Simulink and LabVIEW models representing the cooling of temperature in the filament are shown in Figures 7, 8. It is assumed that once the heater has reached is maximum temperature, it is switched off in order to observe the cooling down process. Eq. (14) expresses the cooling down of the heater.

$$\frac{dT}{dt} = \frac{1}{\rho CpV}[h_{conv}(T_\infty - T) + (T_{sur}^4 - T^4)] \qquad (13)$$

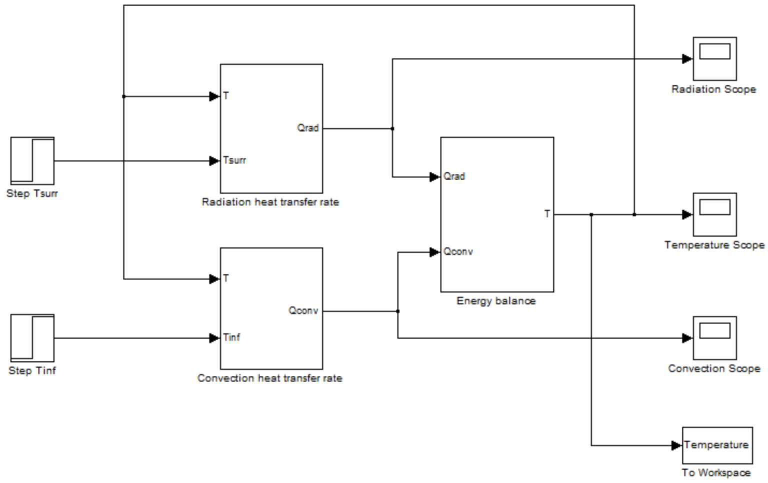

Figure 6: Simulink model of IR heater: Cooling stage

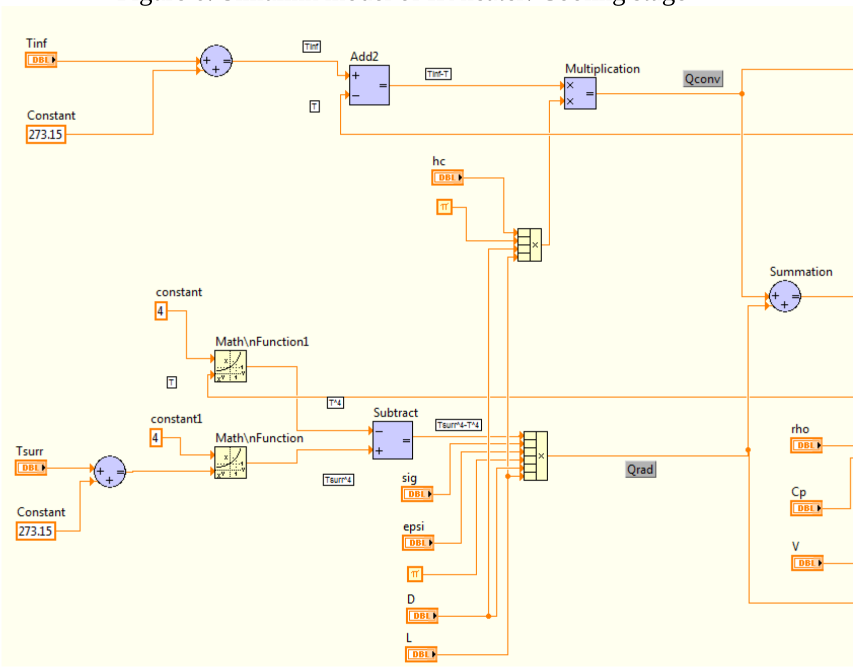

Figure 7: LabVIEW block diagram: cooling stage

- **Reflector**

The heat transfer is defined as one-dimensional conduction in the reflector which itself is considered as an opaque body. The equation in the reflector is defined as in Eq. (13):

$$\frac{\partial T_r}{\partial t} = \frac{k_c}{\rho C_{p,c}} \frac{\partial^2 T_r}{\partial x^2} \tag{14}$$

Since there is an insulation blanket, the boundary condition at the back of heater is:

$$\frac{\partial T_r}{\partial x} = 0 \tag{15}$$

The boundary conditions at the front surface of the heater involve radiation and convection and it is represented in Eq. (16).

$$-k_c \frac{\partial T_r}{\partial x} = h_{conv}(T - T_\infty) + \varepsilon \sigma A (T^4 - T_{sur}^4) \tag{16}$$

- **Radiation heat transfer**

  - **View factor**

The radiation transfer depends on the orientation of the surface in relation to one another according to their temperatures and their radiation properties. The heater has a rectangular shape as well as the surface to be irradiated. They are both parallel to one another as seen below in Figure 8.

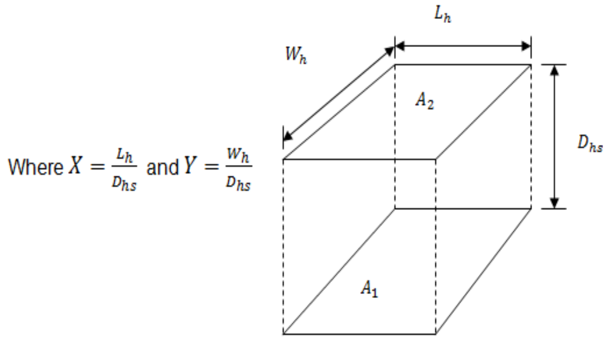

Figure 8: Finite surface: Identical, parallel and directly opposed rectangles.

Eq. (16) expresses the view factor between the FIR heater and the surface to be irradiated.

$$F_{1-2} = \left\{ \begin{array}{c} \ln\left[\frac{(1+X^2)(1+Y^2)}{1+X^2+Y^2}\right]^{1/2} + X\sqrt{1+Y^2}\tan^{-1}\left(\frac{X}{\sqrt{1+Y^2}}\right) + \\ Y\sqrt{1+X^2}\tan^{-1}\left(\frac{Y}{\sqrt{1+X^2}}\right) - X\tan^{-1}(X) - Y\tan^{-1}(Y) \end{array} \right\} \qquad (17)$$

4. Results

The results obtained represent the validation of the IR heater model analysis with a constant ambient temperature and surrounding of T=298 K. Figure 9. shows the rising of temperature in the heating rate simulation as expected and it reaches its maximum temperature as mentioned by the manufacturer. Steady state is reached quickly as the dynamic is very fast within 30 seconds. The maximum temperature expected for the IR-heater is 1200°C for a power rating of P=0.78kW, which confirms the simulation. However above the required voltage, the ceramic may cracked as the stability of filament is no longer supported. Oscillations have been observed when the input voltage is greater than 120V.

It has been observed in LabVIEW front panel (Figure 9) that radiation heat transfer is the main mode of transfer of heat compared to the convection heat transfer. The dynamic is fast which is expected for an efficient heater with a low input voltage (figures 10 and 11).

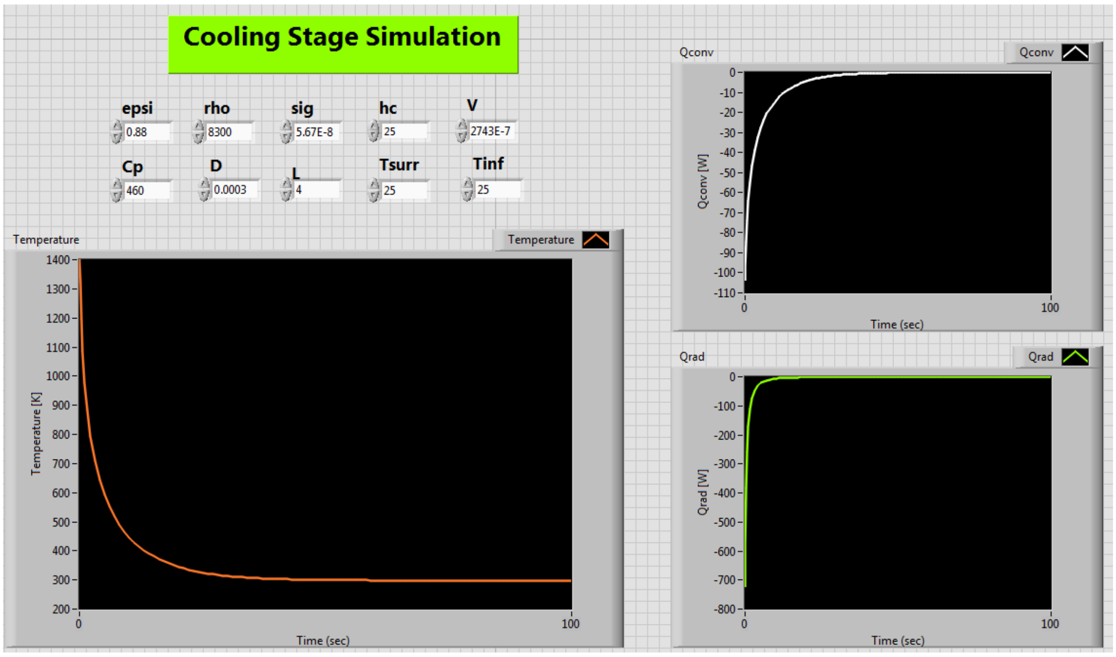

Figure 9: LabVIEW front panel: cooling stage

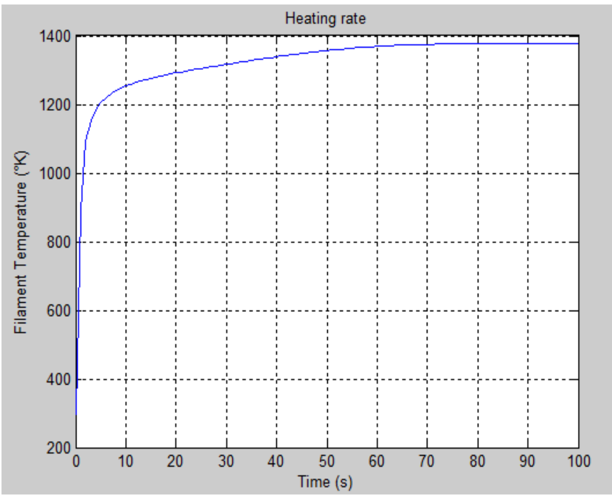

Figure 10: Heating rate of filament wire

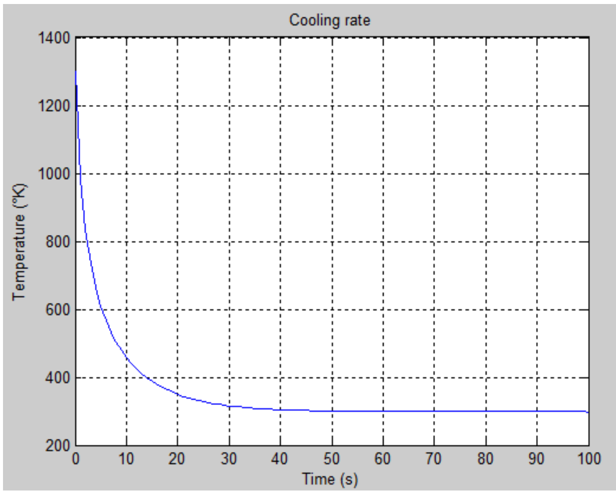

Figure 11: Cooling phase of filament wire

6. Conclusion

A mathematical model of an IR heater was developed in this paper with the purpose of investigating its behaviour during heating and cooling stages. The presented heater is intended to be used for plastic waste gasification via indirect heating of the reactor throughout the heating stage. Simulations showed the heating and cooling of an electrical FIR ceramic heater using popular engineering software programs for model validation. Results are in agreement with theoretical analysis.

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Presenter: The paper is presented by Sarah Guyemat Mbourou.

Enrichment Service Process as a Learning Model

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Abstract

This paper introduces Enrichment Service Process as a learning model bringing new flexibility to teaching and opportunity for re-thinking co-operation with industry - the organisation of tertiary education in regional units. The model is based on a mix of workplace ties and selected local research, development and innovation (RDI)). Students begin studies on a main campus, with, typically, during the second half of a curriculum, a considerable part of studies project-based; realised locally on authentic industry development projects or personal RDI projects. This learning model is vital since there are insufficient campus-based students to meet local companies' demands.
Learning and teaching methodology has changed; students spend more time "on the job" in real work scenarios. Today's subjects and course content emanate from industry, so learning must adapt. Universities must expand integration with corporate life; in return, big business will play a bigger role in the development of education – the search for skilled employees has stiffened.

Moreover, educators' roles have changed to a more collaborative style; usually identified as the work of coaches, tutors or mentors. The role is dynamic and a major idea is for mentoring to support campus students with their professional growth is face-to-face encounters with industry. The aim of this paper is to examine the background information of Oulu University of Applied Sciences (OUAS) students in conjunction with a local company Ruukki – steel construction specialists.

Keywords: *University/industry co-operation, regional networks, project- based learning, teachers' roles*

1. Introduction

The Finnish higher education system consists of two complementary sectors: universities and universities of applied sciences; universities of applied sciences are referred to as polytechnics or AMK institutions. This tertiary education system is being developed as an internationally competitive entity, capable of responding flexibly to regional and national needs [1].

University education: Universities' aims generally are to conduct scientific research basing undergraduate and postgraduate education on it. Universities must promote free research and scientific and artistic education, provide higher education based on research and educate students to serve their country and humanity. In completing such a mission, universities must interact with the community and monitor and strengthen the impact of research findings and artistic activities on society.Under a Universities Act promulgated in June, 2009, Finnish universities are independent corporations under public law, or foundations under private law (Foundations Act); they have operated in their new format since January 1, 2010. Their operations are built on freedom of education and research and university autonomy. Universities confer bachelor and master, postgraduate licentiate and doctoral degrees. Universities work in co-operation with society and promote the social impact of research findings.

University of applied sciences education: Universities of applied sciences train professionals in response to labour market needs and conduct R&D which supports instruction, in particular promoting regional development. Universities of applied sciences are still fairly new, with the first operating on a trial basis in 1991−1992; permanently in 1996. They were based on the institutions which previously provided post-secondary vocational education, developed to form a nationwide network of regional institutions of higher education – polytechnics; by 2000 all universities of applied sciences were working on a permanent basis.Universities of applied sciences are multi-field regional institutions ,focusing on contact with working life and on regional development. The total of young and mature universities of applied sciences students is 130 000. Universities of applied sciences award more than 20 000 polytechnic degrees and 200 polytechnic Master's annually. The system of higher degrees was put in place after a trial period in 2005 and the number of Master's programmes is expected to grow.

Centralisation of higher education in large units to offer students diversified studies and to strengthen RDI is the norm. But this places pressure on regional units located off a main campus. This paper considers OUAS, the main campuses of which are in Oulu (Northern Finland's main city), while its regional unit, Raahe is 75km away [2]. In 2010 a tough decision was made at Oulu University of Applied Sciences concerning the Raahe campus - intake of new full time students ended late in 2011, but intake of adult (part-time) students continues, and RDI activities have increased. This fresh approach means all new young students begin studies on the Oulu main campuses and after two years enjoy a possibility to participate in practical study and training projects implemented in co-operation with industry [3]. This project-based learning is realised at Raahe and conducted by lecturers on the Raahe campus.

In future, work will be fragmented; even advanced study becoming automated through information technology (IT). The labour market is diffusing; now open to global competition, local industry requires attendance on site by all workers. Project-type work requires an ability to endure uncertainty and constant change. Working life requires an increased acceptance of personal responsibility and self-management; a lifetime may include several careers. Diversity and deepening co-operation between higher education and regional companies and organisations is the focus of Finnish higher education development [4]. Management appreciates individuals showing responsibility for attitude and relationships and forming a sound base for the spirit of working.

2. Research Questions and Methods

The Act requires universities of applied sciences to co-operate with their area of environment. Their mission is to cooperate with business and industry and other sectors of the labour market, particularly in their own region, and with other Finnish and foreign tertiary institutions establishments [5]. But the problem remains on how to organise higher education in regional units with few students or with students who study away at a main campus? Can this problem be breached?

This project used qualitative research with on students and companies. In practice this meant researching possibilities of higher education in regional units, to collect feedback data, produce information from companies, interview random sample students and representatives of companies, then to analyse results. Did the learning model solve regional requirements and higher education needs?

3. Enrichment Service Process as a Learning Model

In 2011 the writers began the project, named Kamara. Its goal was to develop a new campus model in Raahe and to empower lecturers. This project was funded by the European Social Fund (ESF) [6]. The most important aim was lecturers familiarized themselves with the model and could use it. Lecturers' face new demands and challenges; also many new possibilities and advantages. Kamara was of critical importance to university staff. During 2011 and 2012, pilots of the new model were in the IT degree programmes, mechanical and production engineering and business economics. Today, the number of students and companies involved has risen above that planned; feedback has been promising. Student numbers is strongly determined by local companies' needs and lecturer enthusiasm. It became obvious lecturers' operational environment shifted from classroom to field – near potential employers. At the same time, mentoring of students' professional growth has progressed.

The Finnish universities of applied sciences (UASs) have been challenged to establish and maintain co-operation with a heterogeneous group of small and medium-sized enterprises (SMEs). Inquires report enterprises satisfied with the level of co-operation and see potential for more; surveys show UASs impacting positively on regional competitiveness, employment and entrepreneurship. In addition, the UASs strengthened regional appeal and improved recognition and development of the regional business sector. Furthermore, typically medium-sized companies received more exposure and variety of co-operation with UASs. Kamara enjoys active co-operation with more than 40 enterprises. The programmes on the Raahe campus means students from Oulu may complete their studies at Raahe by working on projects offered by local companies. This potential is significant. It ensures accomplished staff be available to local industry and commerce; students simultaneously earn study credits and work experience. Changes in the structure of working life and higher education have forced initiatives in these regions to reconsider the future of regional higher education. The need for concrete collaboration has turned into action thanks to Kamara – re-developing organisational structures, operational models and overall culture. So far - all targets set for regional development have been met. \
In Figure 1 is featured the Learning Model.

Figure 1: Enrichment service process as a learning model

3.1. Working life in the future

In the future, no attention will be paid to the length of studies or the age of graduation as transition from education to practical work and vice versa will be flexible. Continuous learning and application skills are required for working life. While Finland's education system is satisfactory, the labour market is undergoing a global revolution and information volumes on the WWW have grown exponentially [7]. At schools and universities, pupils and students respectively must be taught how to acquire information, evaluate its significance then use it. Industry requires staff able to regularly adapt. Ability to learn boosts self-confidence and readiness for change. Mental ability to adapt is vital during crisis situations; teaching institutions must heed people differ and assist all discover individual ways to learn [7]. Everyone's competencies are sought; everyone will be required.

3.2. Teachers' dynamic role for the future

There are two key aspects or challenges which describe the profile of the skilled teacher of the future. Firstly a teacher must be an expert in education. This means being part of a collaborative and pedagogic expert team and to be able to grow from the traditional teacher's profession to a dynamic teacher's role [8]. The essential role is to be a developer of strategy and operation of the educational organization locally and globally. Nowadays, working with students requires an ability to listen and aid the learner to self-motivate. As a mentor, a teacher of the future must also explain collaboration in the workplace. A dynamic teaching profession means mentors have a role as supporters and coaches of the learning process and also adapt to changes in educational culture [8]. Project-based studies allow for this. Moreover, a teacher must be an expert on networking and understand custom-oriented service needs of working life of any particular professional arena. It also means certain change in the teacher identity – fresh collaboration is required between the workplace and the educational organisations.

3.3. Teachers dynamic tools

Internet development has also impacting on the teaching profession; a variety of tools are available. At Oulu a Collaborative Research and Development project (CoRD) has implemented more than 40 pilot projects since 2012. Based on experiences gathered from the projects, the writers developed a generic model on how product development can be implemented as a part of engineering studies. A networked model to support R&D projects at universities of applied sciences was generated to match workplace methodology. Focusing on core know-how requires building an expert network and using it. The site CoRD presents document templates and supporting information for networked R&D projects which make effective work and communication possible. Development of this method and applying it allows educational enhancement creates networks similar to everyday working life. Document templates are freely available to all readers; https://sites.google.com/site/cordproj/ Project-based teaching and learning guidance can be found on the CordPlan site and pedagogical guidance on the CordPeda site. These pedagogical guidelines support higher education vocational teachers to network R&D learning projects. These guidelines were developed at Oulu in the CoRD Project (2010-2013). The development of these guidelines is connected to the design, realisation and assessment of CoRD Project related activities. This type of co-operative process spreads pedagogical expertise throughout higher education communities and networks. https://sites.google.com/site/cordpeda/ . CoRD Project used the idea of pedagogical patterns to collect, update and share knowledge related to pedagogical experiences [9].

Another tool extensively used in practical project-based studying is Optima - online learning environment developed by Discendum and Finnish universities have embraced it. A function model, making it possible to link the general project action environment to several projects, reduces the teaching workload to establish a collaborative environment for R&D projects. Kyvyt.fi is ePortfolio service also developed by Discendum and has been in test use during the study year 2012-2013 at Oulu. It enables staff to support, instruct, and evaluate students. It also makes it possible for students to present skills, completed projects and CVs to companies. After graduation a young engineer can move their digital portfolio, for example, to LinkedIn, the "de facto standard" social networking website for professionals. This social networking website can also be a useful tool for educators to communicate with alumni students. Lecturers at Raahe use the AdobeConnect -network videoconferencing tool and Skype via Google documents. Also developed was the RIKASTAMO portal where local companies and students can meet. The companies a R&D task or project and educators and students can then decide optimum solutions to a problem. Calendar, appointment and project info database application is also available for teachers of RIKASTAMO.

At Raahe is a student training centre - IT-Parkki. It is a co-operative enterprise founded alongside Oulu. IT-Parkki has built networks with regional SMEs; many projects are instructed; http://www.it-parkki.fi/. One important component in the enrichment service process as a learning model at Raahe is the Pehr Brahe Centre for Industrial and Services ICT (PBOL), a joint research laboratory of Oulu University of Applied Sciences, University of Oulu and VTT Technical Research Centre of Finland. It is located in Technopark, close to the Raahe campus. The unit develops products and business and provides companies with research and development services. The research conducted by PBOL is divided into online and software business, distributed software production methods and intelligent software solutions and technologies. The aim is to combine the partners' respective strengths to achieve an internationally competitive operating environment. PBOL provides services as a part of the Softpolis and Multipolis network of Raahe; http://pbol.org/en/index.jsp?link=home .

3.4. Curriculum development

To ensure competitive edge at Raahe a suitable curriculum has been developed. This is implemented in the IT degree programme and for mechanical and production engineering degrees. A typical structure of the curricula is shown in Figure 2. A bachelor's degree in the engineering fields takes four years. During the first two years students learn basic skills in sciences, languages, communication, economics and professional studies. As studies proceed, the quantity of the project-based tasks, practical training and thesis work increases [3].

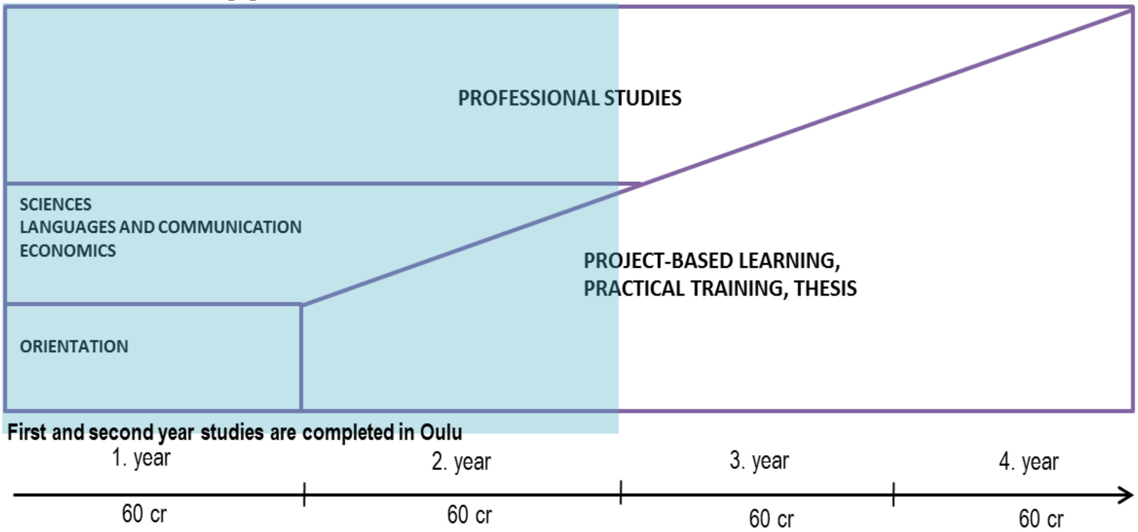

Figure 2: Structure of the curricula

Third and fourth year students play an important role in the RIKASTAMO concept. The writers completed a study concerning students' background information who had completed bachelor theses at local companies. For example, in the last 15 years 202 theses had been tied to the local steelworks – Ruukki http://www.ruukki.com. This study shared points with a survey on summer training completed by Ruukki in 2012. The focus of this study was to consider integration of project studies with summer jobs and training period definitions so that lecturers were also involved in thinking development project ideas for companies and how such projects might fit into the curricula. A summer job, project studies, training, thesis and career, following each other, have been a reality in many personal cases.

3.5. Results

In 2010, an inquiry to local companies in the Raahe region asked if they were interested in the new learning method. More than 40 companies appreciated the co-operation; an encouraging beginning. In 2011 pilot schemes helped implement the learning model - Kamara. Feedback was that companies wanted to continue. Students in the pilot schemes were satisfied and motivated to continue and companies generally offered summer jobs and internships plus opportunities for thesis work and careers. Results indicated the model enabled a regional impact of the Raahe campus on local companies, while making lecturers' procedure more collaborative.

The Raahe campus derives its special nature from unique co-operation models created to benefit students, the companies in the region and educational institutions. Education provided at Raahe strives to be genuinely needs-driven; close co-operation with companies and employer demands operating models and attitude of a novel type.The future of this learning model at Raahe is positive; development in the region is strong and many important decisions and major investment has been realised. Laivakangas Gold Mine opened and the growth of the energy sector (wind turbines firms offered summer jobs and internships to pilot students as well as opportunities for thesis work and career, construction, bioenergy projects and, above all, Fennovoima's decision to invest in a nearby nuclear power plant boosted the economy. Manufacturing/construction requires labour as much as expansion and diversified business and service life.

4. Conclusions

The writers have noticed the model has brought many changes to students, educators and co-operation between tertiary education and enterprises. The seamless co-operation between all partners is a prerequisite for success. There are risks to which attention must be paid - it is important company representatives are active in student recruiting and take part in the development of education more closely.University lecturers and other staff must modify procedure to meet the demands of this learning model. Traditionally students will complete training, write their final thesis and engage in some company projects; an educator's involvement being relatively minor. But with the new learning model the proportion of the teaching staff's contribution increases significantly. Enterprises and companies benefit from students and educators' input into research and development projects. Projects may also involve students from different degree programmes (e.g. engineering and business students) and include more lecturers as tutors. The company selects students according to need; active students can acquire a career and adapt studies to ensure their future. Their lecturers remain responsible for content and quality of the studies, but the new learning model will change their roles. Educators actively liaise with companies in their fields must ensure students grow their professional lives and increasingly appreciate challenges of lifelong learning. Collaboration between the work place and educational institutions will produce skilled manpower for a region and strengthen research, development and innovative work at universities. All types of co-operation between economic life and universities is becoming closer and stronger - some kind of partnership [10].

The new learning model, compared to a traditional school-centered example, is demanding for students. It is vital it provides correct information for students, encouraging them to seize opportunities offered. A new way of learning can improve student motivation and help towards the goal of graduation. This development is a challenge to all, but a great opportunity to answer concrete claims about regional growth.

The most important lesson remains, however, how to study – without forgetting the joy of learning for both educators and students.

5. Acknowledgements

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Presenter: The paper is presented by Timo Pieskä and Leo Ilkko.

Towards a blended learning approach to improving the coordination and supervision of student projects

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Abstract

This paper addresses the problem of coordinating and supervising student projects in a typical South African university environment where student numbers are on the increase and lecturer resources are limited. Blended learning is introduced as an effective means to address this problem, resulting in a move away from the traditional approach, which predominantly involves one directional, face-to-face teaching methods, and its inherent problems. In addition, this paper presents the lessons learned through the coordination and supervision of student projects at both third and fourth year level at the Nelson Mandela Metropolitan University's School of Information, Communication and Technology. This takes the form of a case study using an 'action research-like' approach.

Keywords: *Blended learning, Capstone projects, Software development, IT curriculum, Moodle*

1. Introduction

In 2009 the South African Department of Higher Education and Training mandated an increase in access for students to Higher Education institutions. The growth of student enrolment was approximately 3.25% per annum on average from 2000 to 2009. However, this figure has now increased substantially to 6.2% between 2010 and 2011 [1].

Student projects form an essential part of the Information Technology (IT) curriculum at the NMMU, School of ICT at both third and fourth year levels by providing an integrative capstone type experience. According to the ACM [2], the concept of such a capstone experience towards the end of the curriculum has gained wide support in academia across various disciplines, including computing.

An integrative capstone experience presents the students with a realistic understanding of the IT profession. Regardless of how the core concepts and skills have been presented pedagogically during the initial years, students should be provided the opportunity to use all of their skills together and to understand that no part of an IT system should be treated in isolation [2].

Although there are varying approaches to incorporating such integration into the curriculum, the ACM curriculum states that the creation of a complex system from a set of components is a multidisciplinary team effort that must be planned and executed in a coherent, professional manner [2]. However, a coherent and professional approach towards student projects requires strict coordination and supervision which severely impacts on critical resources.

This paper addresses the problem of coordinating and supervising student projects in a typical South African university environment where student numbers are on the increase and lecturer resources are limited. Blended learning is introduced as an effective means to address this problem, resulting in a move away from the traditional approach and its inherent problems. In addition, this paper presents the lessons learned through the coordination and supervision of student projects at both third and fourth year level at the NMMU's School of ICT. This takes the form of a case study using an 'action research-like' approach.

2. Methodology

The issues addressed in this paper are based primarily on the experiences of the authors who have been involved in the coordination and supervision of third and fourth year students projects over many years. For this reason, an 'action research-like' approach was followed as proposed by Stephen Kemmis [3]. This approach is cyclical in nature and consists of four steps, namely: plan, act, observe and reflect. The cycles took place over a four-year period from 2010 to 2013.

The paper is presented in the form of a case study carried out at the NMMU's School of ICT on third and fourth year student projects, together with relevant literature that supports the key issues highlighted.

As previously indicated, one of the main problems is that of increased pressures on critical human resources owing to the increase in student numbers. Table 1 presents the increase in student numbers at third and fourth year level from 2010 to 2013.

Table 1. Increase in student numbers from 2010 to 2013

Year	Third Year Level	fourth Year Level
2010	66	43
2011	85	54
2012	118	81
2013	148*	111#
** In 2013 the 148 third year student figure equates to 46 student project groups.*		
# In 2013 the 111 fourth year student figure refers to 111 individual student projects.		

The problem of increased student numbers is further escalated by the limited lecturer resources available for supervision. Currently, only 14 lecturers are actively involved in the supervision of student projects in the NMMU, School of ICT. These lecturers are jointly responsible for supervising the combined total of enrolled third and fourth year project students (259 for 2013). These responsibilities include weekly meetings with project students, reviewing of student project document submissions and providing timely feedback to students on these. These supervisory responsibilities are over and above normal academic workload which includes lecturing duties, research and committee commitments. Typically student project supervision equates to approximately two hours per week per student project. In 2013, there are a total of 111 individual fourth year student projects and 46 third year group student projects. This amounts to a total of 157 student projects that need to be supervised by 14 lecturers. In order to ensure fair distribution, each lecturer would be required to supervise on average 11 student projects. At 2 hours per week per student project this amounts to a total of 22 hours additional workload per week.

The following section describes the traditional approach of coordinating and supervising student projects at third and fourth year level.

3. The Traditional Approach

The primary aim of the National Diploma in Information Technology (IT) is to provide the student with a sound theoretical and practical foundation in preparation for a successful career in information technology. "A qualifying student at this level is competent in the development of IT systems in a distributed computing environment, after specializing in the design and production of reliable, cost-effective software products and systems to meet specified needs"[4]. The Baccalaureus Technologiae: Information Technology degree, in turn, indicates that a "qualifying students at this level is competent in applying advanced design, development, implementation and / or maintenance strategies and techniques in the development of Information Technology solutions” [4]. Within the software development qualification, students are taught to effectively solve business-oriented problems. This is achieved through extensive education in computer software, computer architecture, and the analysis, design and implementation of software solutions [5].

The NMMU’s School of ICT offers a three year National Diploma in IT as well as a Baccalaureus Technologiae degree at the fourth year of study which affords a higher degree of specialization. A capstone experience in the form of a project is required at both third and fourth year level in order to ensure that all IT graduates have the opportunity to consolidate their learning over the previous years. Whereas the third year students are required to work in teams to develop a software solution, the fourth year students complete individual projects. Both third and fourth year projects are assessed on a continuous basis and run over a full academic year (two semesters).

3.1. Student Projects at Third Year Level

Since the value and challenges of working in teams is not evident in small-scale projects, third year IT students are required to engage in real world team-oriented projects that extend over a full academic year. This is in line with the ACM [2] which recommends that any capstone experience should incorporate three main elements, namely:

1. Students are divided into teams;
2. Each team is provided the opportunity to participate in a real world project or solve a real world problem;
3. The project takes many weeks to complete.

The third year capstone experience of the NMMU, IT Diploma requires that students integrate knowledge from all prior subjects. The project coordinator is responsible for defining the project deliverables to ensure the integration of such knowledge.

At the beginning of the academic year, students are required to form groups typically of two to five members per group. Group sizes differ owing to the variations in project scope. Thereafter, project groups are required to identify an opportunity or find a real world problem or real world project that requires a software solution. In addition, groups are required to find a willing user to advise them on the business specific needs for the project. These users can be actual clients from industry, a knowledgeable lecturer, or even a post-graduate student who is willing to act as a user. Each project group is also assigned to a lecturer who acts as a project supervisor. Both users and supervisors are expected to hold weekly meetings with project students in order to determine the project requirements and meet the on-going deliverables specified by the project coordinator.

These student projects follow an agile-like approach consisting of four major iterations over the course of their third year of study. Each iteration milestone occurs at the end of a term. The first iteration (Iteration 0 – Term 1) starts with the initial scoping and definition of the project and ends with the delivery of a detailed requirements specification. The primary activity during the second iteration (Iteration 1 – Term 2) is the analysis and design of the core components of the intended system. Project teams are required to present a working prototype of the core components at the end of this iteration. The third iteration (Iteration 2 – Term 3) focuses on extending functionality beyond the core system developed during the second iteration. This iteration ends with a system that meets all the major requirements of the final system. Final acceptance testing, "packaging", and deployment of the final system is required in the last iteration (Iteration 3 – Term 4).

Each of the above-mentioned iterations requires the submission of specific deliverables at predefined weekly intervals. Submission of these deliverables contributes towards an overall project management mark which impacts the final summative assessment. Each iteration is also, subjected to a formative assessment by a judging panel. These formative assessments result in extensive feedback and play a major role in determining the way forward for the next iteration.

Submissions of project deliverables on a continuous basis pose several problems as discussed in Section 3.3. Details of these deliverables are addressed in weekly project lectures and various templates relating to the deliverables are either e-mailed to the students or copied onto a shared drive on an NMMU server.

3.2. Student Projects at Fourth Year Level

During the BTech year a student is required to complete an individual project (fourth year project) which serves to allow the student to demonstrate his/her ability to integrate all prior knowledge and skills which have been acquired in the foregoing qualification (National Diploma: Information Technology). To ensure that those aspects that cannot be adequately presented in a formal classroom setting, an independent capstone experience is required [3]. The student therefore does not work on a team project, as is the case with the student projects at third year level. The fourth year project counts 2 credits towards the BTech: IT degree that spans over a minimum period of a year and is a continuous evaluation module.

Five assessment marks accumulate towards a student’s final project mark. These assessments involve two documentation assessments (during June and October), two judging sessions (during June and October) and a final presentation where all project students present their projects to an audience of academics, IT students and industry partners at an end of year seminar.

Although there are five assessments that count toward the final mark, various additional deliverables are required for the duration of the project. A list of all the expected deliverables and due dates of the fourth year project is communicated to the students at the beginning of the course by the project coordinator. These deliverables include, among others, various written documents to be completed and submitted at planned intervals throughout the year, for which feedback must be provided to the student, to ensure that the projects remains on track.

Due to an increasingly large number of students registering for the fourth year project module annually, dealing with the physical submission of documents in hardcopy, keeping record of submitted documents, as well as providing timely feedback to students, place enormous demands on human resource capacity. The project coordinator is unable to handle all the student projects alone. A supervisor is therefore allocated to each student to assist with project supervision, feedback, guidance and assessment of documentation of the individual student project throughout the year, while the project coordinator is primarily responsible for the smooth functioning of the project and the coordination of documents and feedback amongst student and supervisor. For the project coordinator, this can become an enormously challenging and time consuming task, which is compounded even more by the large number of students and the even larger number of hard copy documents that require assessment and feedback, and which further, must be sent and received amongst the various stakeholders, namely, the project coordinator, the supervisors and students.

3.3. Problems with the traditional approach

Many of the problems that arose with the traditional approach were due to the various formats in which submissions could be made. Most deliverables were required in hardcopy format to allow for ease of readability for both the project coordinator and supervisor. However, at times, these would be e-mailed to the project coordinator and supervisor. The reasons provided by the students included the fact that very often they were not on campus on the hand-in date or that they had a lack of printing credits. This resulted in additional work and stress for the project coordinator and supervisor as they were expected to cater for these multiple formats of deliverable submissions.

In addition, the project coordinator and supervisor found it very difficult to keep track of the specific hand-in dates and times of the various deliverables. Students often missed deadlines and were requested to resubmit work when documents were misplaced. This resulted in an unacceptable level of paper wastage. A further problem is that many students were unable to demonstrate some form of document version control. This problem was worsened by the fact that several group members did not have access to the latest version of the documentation.

These problems resulted in the need to explore other means by which to coordinate and supervise both the third and fourth year projects. It was decided to investigate a blended learning approach to project coordination and supervision by using existing technologies at the NMMU with the expectation that this would address the core problems identified, namely:

- Multiple file formats of deliverable submissions
- Missed deadlines
- Inability to track submission deadlines (record keeping)
- Paper wastage
- Difficulties with time management
- Misplacement of documents
- Lack of document version control
- Inaccessibility and inconvenience of access to documents
- Large volumes of hardcopy
- Monitoring of student progress

As a starting point, blended learning has been considered as a potential approach to facilitate this process, while attempting to address and alleviate the above-mentioned identified difficulties and challenges.

4. Background to Blended Learning

This section commences with a discussion of blended learning, before moving onto a discussion of learning management systems within a blended learning environment. It then focuses on Moodle as a Learning Management System (LMS), where the purpose, features and advantages of Moodle are highlighted to potentially support and enhance student project coordination and supervision at Higher Education institutions.

4.1 Blended Learning

In general, definitions of blended learning indicates it as a “blend” or combination between face-to-face instruction – in individual or group setting; and online or computer-mediated instruction, providing an integrated instructional approach. Hence, the interchangeable use of terms such as “blended”, “hybrid” and “mixed-mode” in literature.

The purpose of a blended learning approach is to combine the best of face-to-face instruction with online instruction, on a broad continuum. No prescribed ideal blend exists, for the two instructional approaches, as the integration thereof, is unrestricted in the ratio of face-to-face instruction used in comparison to on-line instruction. The only guidance for determining the ideal blend for a particular circumstance or instructional setting is to customize the integration of the blend according to the content, needs of the students and the preference of the instructor [6].

However, other definitions look beyond the “blended” or “mixed” structure and focuses on additional features, such as delivery media – ranging from non-technology support to online electronic material and multimedia; and learning activities and events – ranging from individual, collective and self-paced activities to electronic performance support [7].

Dr Hermien Johannes [8], a Teaching Development Professional in Blended Learning at NMMU, specifies blended learning as an enhancement to traditional teaching methods, in that it promotes learning by utilizing web-based e-learning technology as an on-going process.

4.2 Learning Management Systems (LMS)

Popular in conforming to a blended learning environment are learning management systems. A Learning Management System is a software application or web-based technology that “enables the management and delivery of learning content and resources to students” [9]; monitoring of student participation and assessment of student performance [11]. An important feature of a LMS is that it provides a structure in which to organize learning content and resources. It further, allows for real-time bidirectional flow and exchange of information on demand, which promotes convenience for all stakeholders of the learning community (lecturers, students and administrators) as access to the system is available at anytime from anywhere. Phillipo and Krongard [11] denote a Learning Management System (LMS) as the "missing link" that combines present education trends with innovative uses of technology, serving as a "great enabler" of current and future educational initiatives.

4.3 MOODLE

MOODLE, which stands for Modular Object-Oriented Dynamic Learning Environment, is an Open Source Software (OSS) Learning Management System (LMS) that is available free of charge [12] [13]. Aydin and Tirkes [14] claim MOODLE to be the most preferred LMS. It is web-based educational software, which is designed around pedagogical principles, as it is grounded in a philosophy of social constructivism [15] [16] [17] [18]. This means that it promotes a collaborative learning environment, as it provides a platform for structuring, delivery, sharing and exchange of learning content.

MOODLE has many advantages that are aligned with those described for learning management systems and are listed below [11] [16] [19] [20] [21]:

- Structure and organize content - chronologically week-by-week or per topic
- Flexibility and adaptability
- Submission of work in any file format
- Collaboration, communication and interaction - bidirectional flow of information and information exchange
- Staff productivity – effective use of critical human resources
- Convenience – availability and accessibility on demand, anytime, anywhere
- Clear representation of roles - different content privileges/permissions for different stakeholders of the system (students, project coordinator, lecturers)
- Participation monitoring and progress tracking

By incorporating a blended learning approach using MOODLE, these advantages can be realised in the coordination and supervision of student projects. The following section briefly describes the proposed blended learning approach as applied to student projects at third and fourth year level.

5. The Blended Learning Approach

The Nelson Mandela Metropolitan University (NMMU) has, as part of its long-term strategic planning report entitled Vision 2020 considered its future in terms of the rapidly changing and globally interconnected knowledge society. Based on this consideration, two strategic sub-objectives, amongst others, relating to Information and Communication Technology were identified [22].

The first of these two sub-objectives is the provisioning of specialized computing resources in support of teaching, learning and research [22].

The second sub-objective is the empowerment of staff and students to use the technology provided as a normal part of the provision, processes and practices of teaching and learning in a blended learning environment [22].
In line with the mentioned strategic sub-objectives, the open-source MOODLE LMS is currently used as one of the university's learning platforms.

At the beginning of the academic year, the IT project modules are created on the NMMU learn site (http://learn.nmmu.ac.za), alias MOODLE, within the School of ICT of the Faculty of Engineering, the Built Environment and Information Technology (EBEIT). Students are required to login onto the learn site using their NMMU username and password. Each module created on the web site requires that learners enrol for the course using an enrolment key predetermined by the respective project coordinator. The project coordinators at both third and fourth year level are responsible for structuring the respective module learn sites according to the specific project requirements. Section 5.1 discusses the structure and blended learning approach at third year level while section 5.2 addresses this at fourth year level. Section 5.3 describes the problems addressed through using the blended learning approach at each level.

5.1 MOODLE and Third Year Project

Over the past two to three years MOODLE has been explored as an alternative to the traditional approach for coordinating and supervising third year projects. It has been effective in the following areas:

1. *Setting up of deliverables and deadlines* – this is a primary function of the project coordinator. Deliverables and their associated deadlines are typically set at the beginning of the academic year and updated as required. Students have immediate access to this information which is essential in ensuring that they are able to manage their projects effectively. In addition, hand-ins are automatically tracked through MOODLE and late hand-ins can be prevented.
2. *Uploading of templates and other relevant material* – this functionality provides students with the templates necessary to ensure that their deliverables are in the required format. Additionally material is also made available and easily accessible through the use of MOODLE.
3. *Allocating students to groups* – this functionality is important for third year projects. Once allocated to a group, any group member is permitted to submit the various deliverables on behalf of the project group. In addition, group members have the ability to view the documents submitted by their project group. In this way all group members have immediate and easy access to the deliverables relating to their project.
4. *Assigning supervisors to groups* – this provides the supervisors the ability to view and provide feedback on the various deliverables. Project students are therefore no longer required to e-mail or hand-in hardcopy versions of their submissions. Supervisors can provide feedback in the form of comments and/or grading.
5. *Monitoring project progress* – this is done according to the deliverable submissions and their associated deadlines. Those project groups who do not submit deliverables on time can be easily identified by both the project coordinator and supervisor.
6. *Grading of submissions (optional)* – this can be used for formative assessments and to help identify specific deliverables which pose problems for the students. These grades could also be used towards a project management mark although this has not been done to-date.

The many benefits of using a learning management system such has MOODLE for the coordination and supervision of third year projects have already been observed. MOODLE has undoubtedly assisted in addressing the many problems and challenges faced with the traditional approach.

5.2 MOODLE and Fourth Year Project

A means of facilitating the convenient delivery and sharing of learning content in a centralized environment is required, while promoting collaboration amongst stakeholders.

Hence, the following features of MOODLE are currently used for the fourth year project setup, namely: Roles, Resources, Activities and Sections.

Roles are defined for all the stakeholders using the fourth year project MOODLE site. The assigned roles allow specific privileges/permission for different stakeholders (project coordinator, supervisors and students). For example, the project coordinator administers, structures, edits and maintains the fourth year project site and can view all activities of participants, the supervisors can view all content and all students' uploaded documents, but cannot edit the structure of the fourth year project site; the students are able to download and upload documents, from and to the MOODLE site, but each student can only view their own submissions.

Resources, in the form of instructional/explanatory/background material, are made available.

Activities related primarily to documents that students are required to upload as deliverables of the fourth year project module onto the fourth year project MOODLE site at pre-determined intervals during the year. These documents are then accessed by supervisors, when required, and feedback is provided to the student during a scheduled weekly meeting appointment between student and supervisor. The proposed amendments, resulting from the supervisor's feedback, are affected to the document, which is then submitted by the student onto the project MOODLE site. The amended document is submitted onto the fourth year project MOODLE site on a subsequent submission date.

Sections are areas within the fourth year project MOODLE site's Homepage that groups together related resources and activities.

The current setup of fourth year project on MOODLE does not make use of assessments and quizzes; and further the feedback response of supervisors to students is currently not uploaded onto MOODLE. However, the amended document, according to the supervisors suggestions and recommendations, is submitted onto the MOODLE fourth year project site, by the student, at the next submission due date.

5.3 Problems addressed through the Blended Learning Approach

The student projects currently employ face-to-face teaching methods, combined with learning content structured on MOODLE. The main challenges that had to be overcome with the traditional process that the student projects followed were related to the coordination and supervision efforts of the large number of students participating in the project requirements. Other challenges experienced related mostly to a requirement for a central point of delivery of content, and to have on demand and easy exchange of documents between the project stakeholders.

Table 2 serves to show where the utilization of MOODLE for student projects addressed the problems encountered by the traditional approach to coordinating and supervising of student projects as discussed in Section 3.3.

Table 2: Problems encountered with the traditional approach as addressed by MOODLE.

Problems	**Third year project**	**Fourth year project**
Multiple file formats of deliverable submissions	X	X
Missed deadlines	X	X
Inability to track submission deadlines (record keeping)	X	X
Paper wastage	X	X
Difficulties with time management	X	X
Misplacement of documents	X	X
Lack of document version control	X	X
Inaccessibility and inconvenience of access to documents	X	X
Large volumes of hardcopy	X	X
Monitoring of student progress	X	X

This confirms that a blended learning approach towards the coordination and supervision of student projects satisfactorily addressed most of the problems with the traditional approach.

6. Conclusion

This paper reports on the lessons learned from moving away from the traditional approach of coordination and supervision of student projects towards a blended learning approach utilising MOODLE. This partially addresses the main challenges relating to critical lecturer resources and increased student numbers.

In future, additional improvements to student projects using MOODLE will be considered including enhancing tools. One such tool is MOODLE Workshop that will be explored for allowing effective document feedback and information exchange amongst stakeholders. Another tool to be considered is

MOODLE Turnitin, which can be used for checking plagiarism of student project submissions. Further, future research includes establishing the perceived effectiveness from a student and supervisory perspective.

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Modes and Methods in ICT and/or Engineering Education

The use of agile systems approach to enhance the academic performance of tertiary level ICT students

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Abstract

The number of students passing computer programming modules at the Vaal University of Technology at first year level is low. Only with the second attempt, do most students pass. This delay results in most students completing their National Diplomas in four or even five years. One possible solution for this problem is the introduction of a collaborative (cooperative) pedagogical approach, where students will develop software in teams by using agile systems approach. This study endeavours to investigate if agile methods will have a positive impact on Information and Communication Technology (ICT) students at the Vaal University of Technology (VUT). An experimental study and a survey (i.e. two research methods) was conducted over a period of a single semester with students registered for the module Information Systems 1.2 (i.e., module code AIISY1C). Firstly, a quasi-experiment is executed, with a group of students being introduced to agile approach, while another group will continue with the normal single student programming approach. This will establish whether agile systems approach can improve students' academic performance. A survey was then performed before and after the implementation of agile methods to establish the possible change in a student's attitude towards software development, and a career in software development. It is postulated that a mark difference between the performances of learners introduced to agile methods will result, in comparison to those that were not introduce to agile methods. It is also postulated that a more positive student attitude towards e-learning will be established.

Keywords: *Agile methods; Extreme Programming (XP); collaborative learning, cooperative learning, e-Learning.*

1. Introduction

According to the previous minister of education, the honourable Naledi Pandor (2006), science, mathematics and ICT plays a vital role in social and economic development. Developing countries need to enhance their human and institutional capacity in mathematics, science and technology, if they are to succeed in their developmental goals. She further stated that South African learners' performance in the Trends in International Mathematics and Science Study in 2003, 1999 and 1995, confirmed that South Africa's most important educational priority was to expand mathematical, ICT and scientific capacity of learners. In South Africa, provision is made for learners to prepare for a career in IT by offering ICT modules at tertiary educational institutions. One of the learning outcomes of IT focuses on the design and development of appropriate computer-based solutions to specific problems using programming (i.e. software development). From the above it is clear that an intervention is needed that will address the shortage of students in IT, possibly by introducing new innovative techniques in teaching and learning.

Agile systems approach seem advantageous to education in general and might lead to a retention in the number of university students enrolled in IT courses, the question still remains whether agile methods could have an effect on students' enjoyment and their view of the importance of programming, the subject IT and a career in IT, and whether it could possibly result in an improvement in their enrolment and the retention rate in ICT at higher education level.

In this article, a current study in progress at the Vaal University of Technology is reviewed. First, background to the study is provided, followed by review of the research method(s) being followed. Finally, a conclusion is provided, outlining the possible contributions of the study to the research area of e-learning.

2. Background

An historical perspective on SDMs shows that they came into being to address deficiencies in existing techniques of software development and to introduce some rigour into the software development process [1]. The systems (or software) development life cycle (SDLC) was one of the first of such methodologies to be introduced into the academic community and it subsequently became the SDM for the 1970s [3]. It was developed in an attempt to produce information systems that were delivered on time, within budget and closer to the requirements of the user, analogous to the goals of present day SDMs.

According to Beck [2], the term Agile SDMs refers to specific methodologies that share the principles and values as stated in The Agile Manifesto, highlighting twelve principles through which a methodology can be identified to be agile, namely:

- The highest priority is to satisfy the customer through early and continuous delivery of valuable software.
- Welcome changing requirements, even late in development. Agile processes harness change for the customer's competitive advantage.
- Deliver working software frequently, from a couple of weeks to a couple of months, with a preference to the shorter timescale.
- Business people and developers must work together daily throughout the project.
- Build projects around motivated individuals. Give them the environment and support they need, and trust them to get the job done.
- The most efficient and effective methodology of conveying information to and within a development team is face-to-face conversation.
- Working software is the primary measure of progress.
- Agile processes promote sustainable development. The sponsors, developers, and users should be able to maintain a constant pace indefinitely.
- Continuous attention to technical excellence and good design enhances agility.
- Simplicity, which is the art of maximising the amount of work not done, is essential.
- The best architectures, requirements, and designs emerge from self-organising.
- At regular intervals, the team reflects on how to become more effective, then adjusts its behaviour accordingly.

In order for a methodology to be deemed as being agile, the most important characteristic is that it needs to be able to adapt quickly to change. This adaptability is achieved through the techniques and tools of the particular methodology. These most commonly known agile methodologies include eXtreme Programming (XP), Agile Unified Process (AUP), Adaptive Software Development (ASD), Dynamic System Development Method (DSDM) and Lean Software Development (LSD).

According to Beck [4], the use of XP in industry has been claimed to provide significant benefits and there seems to be potential in the use of the methodology for student projects. In addition, according to Adams *et al*. [1], the use of XP is common in most fields of software development. In a study done by Zhang [7], it was found for example that agility is widely accepted in the manufacturing industry as a new competitive concept.

In educational institutions, traditional programming usually take place in a computer classroom where the lecturer focus on syntax, logics, concepts, and analysis of program codes through lecturing and discussion. Such method of instruction limits learning effectiveness as students have limited opportunities to practice programming skills and lecturers cannot be sure if the learning context suits each student [[5], [6]]. Moreover, learning programming is not easy for many students, especially novices and those without relevant background. The utilisation of cooperative programming learning activities into instructional may offer a potential solution to problem. Furthermore, possible further benefits include students capitalizing on one another's resources and skills, evaluating one another's ideas and monitoring one another's work. However, Williams *et al.* [[5], [6]] highlights that these premises must be further tested in different educational environments with different levels of students. This study will aim to confirm whether agile methods could play a vital role in improved ICT students' performance at tertiary level.

3. Research Method

It is generally known that academic research can be classified into one of four research paradigms (i.e. positivist/post-positivist, interpretivist/constructivist, transformative, pragmatic) [4]. A study must therefore specify which paradigm it will use, since it is thereby constrained to specific ontological, epistemological and methodological prerequisites. This study is aligned with the positivist/post-positivist research paradigm.

The nature of this study warrants the use of quantitative statistical analysis on the effect of using agile systems approach on the academic performance and learning of students. An experimental study and a survey (i.e. two research methods) are being conducted over a period of a single semester with students registered for the module Information Systems 1.2 (i.e., module code AIISY1C). Firstly, a quasi-experiment is executed, with a group of students being introduced to agile methods, while another group is continuing with the normal single student programming approach. This will establish whether agile methods can improve students' academic performance. A survey is being performed before and will also be performed after the implementation of agile methods, to establish the possible change in a student's attitude towards programming.

The survey is implemented by using a questionnaire, issued to each participant (i.e. students in the Information Systems 1.2 class) in the study. The results obtained, in combination with the results of the quasi-experimental study, which related to assessment marks, will be used to fulfill the research objectives. The statistical analysis is being carried out with the aid of the SPSS version 17.

4. Conclusion

The main objective of this study is to establish the viability of using agile systems approach in e-learning, compared to current single student programming approach. Naturally, to confirm this, secondary objectives are being pursuit, including the confirmation of the impact of agile methods on the enjoyment level of programming of students, the effect of agile methods on the academic performance of students and the impact of agile methods on the attitudes of students to e-learning. It is further envisaged that the use of agile systems approach will relieve the burden on lecturers, since students will no longer view teaching staff as their sole form of technical information. However, these premises will only be proven or disproven with the completion of the study.

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Emergence of robotics in Brazilian public education projects

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Abstract

This article discusses technology relating to education and in context proposed public projects. A National Education Plan in Brazil has stressed the importance of computers and Internet access for basic and higher education, but use of that technology in public schools remains minimal. At private schools, however, there is infrastructure for the training of human resources and study. Government has agreed on the development of education and research and this paper examines federal government schemes focused on education technology, such as the Roboceti Project, founded by the Ministry of Education. Its goal is to enable technologies and educational methodologies to implement the demands of educational robotics. Specialised educational tools have been developed for tertiary students to plan careers in science or technology; at schools level government must focus on technology.

Keywords: *Technology, education, public policies, robotics*.

1. Conception of Technology

Technology can be explained as the innovation of something that, at certain point, has practical application of knowledge to facilitate the life of mankind in contemporary society. However, the definitions are not easily understood or embedded in different areas as important as they are. Technological advance is nothing more than change to help develop life skills and understand. In that sense, knowledge alone is not enough; it is deeper understanding of research and reasons for that knowledge that is vital - know-how is what alters the dynamics of a society [2]. That is where technology has its role. In education, for example, to arrive at a more consistent and specific definition of technology, it is required to help to analyse information of an y kind, be it state policies or projects to understand how the government seeks to elevate levels of knowledge and discover. This paper seeks to discuss, using theoretical analysis the methodological stamp of government policies, examine laws governing such practice and highlighting the benefits of technology in the educational process.

2. National Education Plan and Technology Relationship

In the Brazilian National Education Plan (PNE – 2011-2020) [3], there is an appreciation of the role of technology in education. The writers focus on clauses 7 and 9 of PNE which highlight computer and Internet access to basic education pupils as well as associated technologies to assist students through to tertiary education:

> “Goal 7: *To promote the quality of education at all stages to improve student flow and learning [...]*
> Strategies:
> *7.14) Create speedy access to the WWW to triple the number of students at all levels by 2020 and promote pedagogical use of information technologies and communication networks[...]*

> Goal 9: *Raise the literacy rate of the population aged 15 or more to 93.5% by 2015 and by the end of the term of the NAP eradicate absolute illiteracy and reduce adult illiteracy by 50%. [...]*
>
> 9.11) *Implement technological training of all sections of society and link all state and private education systems through extension activities developed in vocational technical centers by use of technologies that promote effective social inclusion and productivity [4].*

Thus, the writers highlight state concern to promote active access to the digital world, since the availability of powerful computers with Internet in schools, combined with formal education, would enable students to navigate worlds never before seen, while stimulating study.

Educators need access to such technologies to support their students; to provide encouragement for research and to enable application usage through computer programmes to facilitate studies. However, the use of computers in schools remains limited - especially in public schools,: the Internet Management Committee of Brazil has stated that even with investment in the introduction of information and communication technologies (ICT) in schools, effective use of computer and Internet activities by students remains a challenge [5].

Public school teachers remain untrained in digital skills. Also, use of computers is restricted to the basics of machine management and Internet surfing, classroom computer specialised programme activity is rare. Internet is an area in which teachers try to use ICT more, with 65% aware of new technologies [6]. But they are hampered by archaic speed of access; implementation is another problem area leading to indiscipline and delays in meeting educational deadlines. A possible solution would be the introduction nationally of Wi-Fi connection.

Infrastructure at private schools is better and, 36% of teachers use ICT against 24% at public schools. In text interpretation the disparity is 26% and 16% respectively [7].

There is a paradox in what is proposed by PNE as digital inclusion and reality in schools, in general - educators have little chance of fulfilling state targets because of the parlous state of digital technology

3. The Law of Informatics

To connect teaching and informatics technological growth and advancement in national development are the objectives of the Law No. 7232 of October 29, 1984, which provided for a National Informatics Policy; this has not happened...The Act sought to empower Brazilian society through computer-related activities - support for social, cultural, political, technological and economic - and also highlighted incentive to reduce costs, thus stimulating the economy and creating international competitiveness [8].

It is vital to elevate the Brazilian economy, towards First World nations, yet the writers find it curious that a relationship between informatics and education was not mentioned. As said by Garcia [9]: "Do not make a country without education" and this education must go together with technology."

Lima [10], five years ago, had already encouraged action at state level to place education at the centre of intellectual activity, enhancing investment in scientific research and a realisation of the importance of technological innovation.

Reluctance to introduce technology to elevate development and popularise education and research is the direction to take, but projects and public policies must also handle issues of infrastructure (for educators and students) and modern technical support.
There has been some government action:

- *Pronatec* (National Access to Technical Education and Employment) - created by the federal government in 2011, to expand the range of courses in vocational and technological education.
- *Ciências sem Fronteiras* - a programme seeking to promote the consolidation, expansion and internationalisation of science and technology, innovation and competitiveness through exchange. The initiative is the result of joint efforts of the Ministry of Science, Technology and Innovation (MCTI)

and the Ministry of Education (MEC), through their respective funding agencies - CNPq and Capes - and Departments of Higher Education and Technological Education MEC. The project promotes student exchange, so that graduate and postgraduate students carry out internships abroad to stay in touch with educational systems using innovative technology.

- *REUNI* - Support Programme for the Restructuring and Expansion of Federal Universities; its main objective is to broaden access and retention of students in higher education.
- *Federal Institutes* - The Federal Education, Science and Technology colleges are institutions of higher education, basic and professional, specialising in offering vocational and technological education in various learning modalities, using technical and technological techniques.

4. Programmes/Projects to Promote Use of Technology

This section presents five federal government programmes focusing on technology for education. It also details a project founded by the Ministry of Education (MEC), through the Department of Vocational and Technological Education (SETEC), which reflect the scope of technology applied to education.

4.1. National Programme of Educational Technology

National Educational Technology is managed by the MEC - signing contracts involving electronics has helped promote integration of technology in public education. The programme covers three areas:
1. Equipping the education environment with computers and associated technological resources;
2. Training school representatives in use of modern technologies acquired by a school;
3. Acquiring digital educational content and multimedia information systems via the Department of Distance Education

To be part of this, schools and tertiary institutions require infrastructure necessary to guarantee correct functioning and implementation of support, maintenance and training of technical staff in the use of equipment and resources. The concept of technology includes physical and software resources and the training of school representatives increases the likelihood of effective use of resources.

4.2. Money Direct to School Programme (TSA)

The programme is available to municipal, state and district elementary schools states; also to private school, and administered by non-profit organisations.

The TSA’s role is to financially assist schools by improving physical infrastructure and educational facilities to raise levels of performance.

4.3. Implementation of Multifunction Rooms

The two necessary conditions for participation by schools are:
1. Joint Action Plan;
2. Pedagogical project offering assistance to those with special needs.

The programme aims to distribute equipment, furniture and didactic/pedagogic materials to cater for people with specific needs.

4.4. Program Professionalized Brazil

Focusing on regional characteristics, Program Professionalized Brazil aims to improve integration schools’ social, economic and cultural life; student training in needs of the working world around them follows. The resources provided help in construction, expansion and renovation of rooms, purchase of furniture, equipment and establishment of labs (mostly computer labs) and security systems.

Prerequisites for schools’ participation are:
1. Signature of the Accession Plan Goals All for Education Commitment;

2. Preparation of the Joint Action Plan of Brazil Professionalized, taking into account integrated training (high schools and professionals);
3. The return of at least 1% of finance made available.

These interventions, alongside NET, can also be used for teacher education in the sciences.

4.5. Basic Education Development/Enhancement of Education Professionals (Fundeb)

Also funded by the FNDE, this is one of best known government programmes associated with development of basic public education.

Fundeb resources are distributed automatically according to student numbers. Money is also available for technological equipment, teacher training and school infrastructure.

4.6. Roboceti Project

Roboceti - How Robotic Instrument Training of the Federal Institutes of Science, Education, Technology and Innovation - was founded by the Department of Technological and Vocational Education (SETEC), co-ordinated by the Federal University of Rio Grande do Sulk, with activity and research centres located in Baiano, Fluminense, Goiás, South Rio Grandense and Sul Rio Grande.

The goal is to implement educational robotics. To do this a survey of federal institutes will develop their activities in an integrated manner, regardless of areas.

Educational tools - hardware, software, manuals, tutorials, and small robots- have been developed, with guidance provided via the Internet on a Roboceti home page – http://roboceti.ifrs.edu.br – for federal institute students to increase their interest in careers related to science, technology, engineering and mathematics. Stimulation of students across the spectrum is considered core priority.

The project includes forming Polos (multipliers), each linked to a participating institution, to spread knowledge Educators are trained in correct use of educational materials.

The project promotes events (shows, competitions, robotic challenges) to apply methodologies and technological tools developed and to serve as stimuli for the study of sciences and technology.

Roboceti is fronting improvement in the academic performance of participating students and furnishing all with skills required to develop tools for research in several area. Students with lessons involving robotics have increased general educational interest; general grades have improved.

There is a tendency to view technology in schools simply as a room full of computers, however, it should be realised it means enhancement of technology; equipment, software, curricula and, importantly, teacher training.

5. Characteristics of Today’s Technology in a Schools Context

The teaching learning process has become increasingly challenging from the plethora of information available. Technologies related to education are a major interest area and afford a rethink of the educational act covering diverse theoretical perspectives and methodology.

Cell phone, smart phone, tablet and other devices of communication and closer relationship make the young far more involved than most in education. The young still have battle to use word processors and spreadsheet; in the latter case, knowledge of logic and mathematics are essential and students are often unable to apply requisite formulae learned. An inexpensive robot promotes understanding and remedies difficulties in training - its approach softens the notions of logic and mathematics for many. Schools are avenues to introduce such interventions and lead education 8into the modern technological age.

External teaching adds much to the education process. Pressure to follow the modern technological trail makes the teacher, feel the increasing need of visits and interdisciplinary projects to attract their students' attention ; while long hours makes this difficult; modern technology would ease such a burden..

Teenagers today have become aware of the technological revolution – they also know their teachers must be as adept as they in the mastering of this educational blessing to help to modernise all Brazilian society.

6. Conclusions

The expression *technology* in education is closely linked with computer labs - software and Internet; its inclusion in projects involving new methodologies in a schools school context vital for all.

Investment must be in technological advance and teacher education. The life cycle of such objects and return on investment depends significantly, therefore, on understanding the importance of technology, maintenance and training of teachers. The Roboceti Project has a goal to develop technologies and educational methodologies to implement educational robotics via the spread of multipliers responsible for training in technological educational material.

Legislation, guiding manuals and analysis of public policies sometimes limit the concept of technology, but the truth is Brazil is on the threshold of technological advancement … focus in this area is vital.

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Technology for Sustainable Development

University-community Engagement

A Model of University-Community Engagement in Engineering Education

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Abstract

Universities can play a vital role in the education and life-long learning of individuals living in their surrounding communities. By leveraging their resources and human capital, universities can be change agents for academic science and engineering programs. The University of Southern California through its Biomimetic MicroElectronic Systems Engineering Research Center (BMES ERC) has established a comprehensive and innovative outreach initiative, designed to integrate science and engineering principles into the curriculum of K-12 schools. The Center has established long-term partnerships with schools and community organizations in the greater Los Angeles area. It has tailored its outreach activities to the specific needs of stakeholders including students, teachers, and parents. Programs that have been established through the USC-Community partnership include the Science for Life program to increase science literacy of elementary school children and the Engineering for Health Academy, a multi-year course of study in biomedical engineering at the high school level. BMES ERC outreach efforts also include the Research Experience for Teachers summer program that matches educators with USC laboratories. Working with the teachers, Center personnel facilitate the translation of their research experience into inquiry-based science and engineering curriculum that they take back to their classrooms. The BMES ERC also works with adults in the community through informal educational activities that highlight the importance and relevance of science and engineering to everyday life. This paper discusses key components of a robust university-community partnership. It shares best practices and lessons learned from the Engineering Research Center's 10 years as a National Science Foundation Center of Excellence. Many of the Center's science and engineering education outreach practices may serve as adaptable platforms for the development of university-community partnerships around the globe.

Keywords: *University/community engagement, Engineering outreach, Pre-college education.*

1. Introduction

Universities have a broad influence on K-12 education in the U.S. Faculty at universities serve as policy-makers and as leaders of educational reform. The spectrum of university-lead educational research is wide-ranging including topics on how students learn, the utility of technology as instructional tools, and the effects of socioeconomic factors on student motivation. The education of pre-service teachers in content areas and their training in pedagogic methodologies as well as the continued professional development of in-service teachers, has traditionally been the purview of universities and colleges. In addition to these well-established links, informal partnerships focused on outreach programs are common between institutes of higher education and their surrounding communities including neighbourhood K-12 schools [1].

As intertwined as the connection between institutes of higher education and the K-12 system is, there is a tangible disconnect as well. This stems in part from the fact that the two systems have historically developed separately, report to different governing bodies, and make policy decisions often in isolation of one another. This disjuncture has led to the development of institutional cultures that frequently do not understand one another, making it challenging to establish a truly continuous K-16 educational pathway.

U.S. elementary and secondary students score below their peers in science and mathematics as measured by the Trends in International Mathematics and Science Study [2] and the Program for International Student Assessment [3]. Multiple complex factors contribute to these results [4] but recognition that the education of our youth is the responsibility of society as a whole, including institutes of higher education, is gaining favour [5]. No longer can K-12 schools be expected to educate children in isolation, particularly in subjects as complex and mutable as science. Robust partnerships with institutions of higher education through outreach programs may serve as mechanisms to impact student learning outcomes. This paradigm may be particularly timely in states such as California that have agreed to adopt the Next Generation Science Standards (NGSS). The NGSS differ from previous science standards in a number of ways including the integration of engineering concepts and the assessment of students not only in core concepts, but in science and engineering practice as well. This will lead to considerable work for K-12 teachers as they design and implement inquiry-based curriculum that address the NGSS. Potential barriers to the development of robust science curricula are many and include the lack of confidence expressed by K-12 teachers in teaching science [6]; [7] and introducing engineering concepts and practices into their classrooms. [8]; [9].

This paper examines the characteristics of university/K-12 partnerships. It delineates some of the hallmarks of a robust partnership and describes some of the challenges. Using outreach programs established between the University of Southern California and community schools as examples, the author describes best practices that may be adaptable by those interested in establishing university/K-12 partnerships of their own.

The organization of this paper includes a general description of what the author considers important attributes of university/K-12 partnerships. Following the general description of each characteristic are examples of how the BMES ERC/K-12 partnership infused those attributes into its outreach programs.

2. Characteristics of Robust University/K-12 Partnerships in Science and Engineering

Reciprocity

A key requirement for establishing a strong university/K-12 partnership is reciprocity. Both partnering institutions must mutually benefit if the collaboration is to be long lasting and effective. Each partner must complement the other, find common ground, and play to their particular strengths.

Depending on the focus of the outreach program, benefits to the university include the opportunity to conduct education research, the chance for its “science content experts” to improve their communication and pedagogy skills, and the opportunity for the university to enhance its status in the local community. K-12 schools may benefit from the partnership by gaining access to professional scientists and engineers who serve as consultants, mentors and role models. Specialized equipment and materials not commonly found at K-12 schools may be available through affiliation with the university. Field trips and laboratory visits to the university can help students contextualize what they are learning in their classrooms. A well-structured partnership will leverage the resources of both partners and create a mutually respectful environment that benefits all stakeholders.

The BMES ERC in partnership with a local high school established the Engineering for Health Academy (EHA) [10]; [11]. The EHA is a small learning community comprising administrators, teachers, students and counsellors at the high school and research scientists, engineers and students at the university. High school students interested in the connections between medicine and engineering apply to the EHA program as 10th graders and transition through a series of four core courses over a three year time span. The EHA curriculum, which incorporates biomedical engineering principles and practices, was developed by high school teachers in consultation with university science and engineering faculty. As 12th graders, the high school students are matched with university laboratories where they become members of research teams. University students and postdoctoral fellows serve as mentors to the young scholars and guide them in year-long investigations that culminate in presentations at science and engineering fairs hosted at the high school, district and state levels. The intense and rigorous preparation of the high school students in the EHA program increases the likelihood that they will pursue and succeed in post-secondary science and engineering degree programs.

Personnel

Key personnel from both the university and K-12 school need to be identified early in the establishment of the partnership. These individuals must have a shared vision of the outreach program and the authority to carry it out. Developing and implementing an outreach program requires a great deal of time and flexibility. The university and K-12 institution have their own cultures and problems will invariably arise from a lack of understanding of the respective bureaucracies. To minimize this situation, the outreach leaders should become familiar with their counterparts’ culture and be prepared to work within the restraints of the systems. For example, K-12 teachers work on a rigidly defined bell schedule. Most of their day is spent in the classroom making it difficult for them to talk on the phone or attend meetings with their university collaborators without making arrangements well ahead of time. A possible resolution to this issue is the hiring of substitute teachers to allow the K-12 educators to meet with their university partners during the regular workday.

In the case of the USC outreach program, a high school teacher with ten years of experience was hired as an independent contractor to the BMES ERC. This arrangement enabled him to assume the position as outreach coordinator at the university but retain his relationship with the high school. Prior to joining the high school, the teacher earned his Ph.D. in science and conducted research at the university level. He was, therefore, familiar with the institutional cultures of both partners and was able to navigate through both systems. Over time, as the outreach program expanded and added new initiatives, the teacher was offered a part-time faculty position at USC allowing him to apply for federal grants that helped to support and sustain the university/K-12 partnership.

Clear Goals

It is important to conduct a formal needs assessment to determine if the university can address the issues of concern to the K-12 outreach partner. The match between the university and K-12 partner needs to be a natural fit, leveraging the strengths and resources of the university to address the particular needs of the K-12 school. Clearly identified and realistic goals of the outreach program have to be articulated and consensually agreed upon. The scope and expectations of the outreach program should be commensurate with the human and physical capital of the university and K-school. It is often more realistic to start off small and build capacity slowly. Once an outreach program builds a foundation and establishes a reputation, it may be possible to expand and launch new programs that evolve from that infrastructure.

The BMES ERC Science for Life outreach program started out working with third graders at an elementary school in the Los Angeles Unified School District [12]. Over ninety percent of the students are Latino/a and come from families living below the poverty line. A majority of the students are English-language learners and the school had scored in the lowest decile as measured by the California Academic Placement Index. Very little science instruction was evident in the classrooms. Based upon a needs assessment, the BMES ERC/School partnership established the following goals:

1. To integrate science and engineering principles into the curriculum of elementary students
2. To infuse elementary education with the excitement of discovery
3. To develop a culture of connectivity in which motivation for and knowledge of science is transferred from science practitioners to successively younger generations of students
4. To increase science literacy among a population of students who have traditionally been under-represented in the science and engineering fields.

Using research of the BMES ERC as focal and reference points a series of grade level science modules were designed by university faculty members working collaboratively with elementary school teachers. The SFL modules are composed of a series of lessons that are age-appropriate, standards-aligned, and incorporate inquiry-based learning exercises demonstrating scientific discovery so that students learn science by doing science. Lessons are taught in the classrooms to small groups of students by USC faculty and undergraduate and graduate students. This paradigm offers elementary students direct contact with actual scientists and engineers and the mentors' enthusiasm for science is contagious. The elementary teachers receive training in science content and techniques by university faculty consultants and the university mentors are instructed in pedagogy by the elementary teachers. Having established a proof of principle in the third grade, the SFL program has since been incorporated into the fourth and fifth grades with plans to expand to every grade level from kindergarten to sixth grade.

Buy-in

When establishing an outreach program it is important to know from whom to get support. Depending on the scope and nature of the program, approval may be required at the university level from the dean, department head, or an individual faculty member. At the K-12 level, approval must come from either the superintendent or school principal. Once the outreach program is granted institutional approval, personnel who will design, implement, evaluate and coordinate the program need to be selected. Their selection depends on the specific goals of the program and their duties and responsibilities need to be clearly defined and communicated.
University approval for the BMES ERC outreach program was obtained from the Center director. The NSF mandates that all engineering research centers have a K-12 outreach component and university faculty who are part of the BMES ERC understand their obligations to participate in outreach activities.

Mentoring is a central tenet of all BMES ERC outreach initiatives creating a culture of connectivity whereby knowledge and skills in biomedical engineering is transferred from research faculty to postdoctoral fellows and students at the university to teachers and students at the K-12 level [13]. University mentors hone their communication skills by passing on their science and engineering knowledge to the K-12 students and teachers. Mentoring is also a way for members of the university to give back to the community. The benefits derived through their involvement as mentors have helped to assure buy-in of the outreach program by university personnel.

At the K-12 level approval for BMES ERC outreach programs is granted by the principals at each of the partnering schools. K-12 teachers have bought into the program because BMES ERC-derived curricula augment the schools' existing curriculum and do not add to the teaching load. The curriculum is student-centered, inquiry-based and helps students contextualize what they learn in class. The elementary school teachers were particularly wary of the university/K-12 partnership at first. Many of them had minimal formal training in science and none of them had any experience with teaching engineering. They recognized the benefits of an inquiry-based science curriculum, but were acutely aware of the challenges they faced in developing and implementing lessons that were rich in hands-on activities. The assistance they received in curricular design from university science and engineering professionals as well as from pedagogy specialists, helped to dispel their initial reluctance to collaborate on the outreach programs. The teachers also appreciate the assistance the university students offer them, whether as mentors and role models to their students, or as extra sets of hands in the classroom. The K-12 teachers have become the strongest advocates for the outreach programs.

Location

Regular communication and contact between outreach partners is essential to assure commitment to a university/K-12 affiliation. Many types of outreach entail the bi-directional movement of people, and travelling between partnering institutions will impact outreach programs with regard to time and costs. More time spent travelling translates into less time interacting in outreach activities. Of course, some forms of communication and interaction may well be served electronically through email and video-conferencing, but face to face interactions should not be underestimated in establishing dynamic partnerships that are based upon familiarity and mutual-respect.

When a university is located within close proximity of the people it serves, its outreach programs have the opportunity to impact not only school-age children, but their families as well. Interest in the well-being, safety, and economic health of the local neighbourhood becomes a vested interest and shared responsibility of all community stakeholders, including the university. Unfortunately, universities located in poverty-stricken areas are frequently viewed with suspicion and indifference at best, by the local community. However, with their vast resources and concentration of professionals, universities may be a part of the solution to many neighbourhood concerns, including problems within the public education system. Engagement with the local community as a partner, offers the university the opportunity to enhance its image and build strong public support.

The BMES ERC is housed on the Health Sciences Campus of USC. The campus is located in a commercial and residential section of East Los Angeles. The surrounding neighbourhood is made up of low income housing and industrial warehousing. The community's population is predominantly Latino/a of lower socio-economic status. Traditionally, the Latino family is a close-knit group and the most important social unit. In an effort to involve family members in the education of the elementary children, BMES ERC's Science for Life outreach program hosts an annual Family Science Discovery Day (FSDD). Objectives of FSDD include: (1) to demonstrate to parents and other extended family members what the children have been learning in the Science for Life modules, (2) to directly engage the entire family in STEM discovery activities that are informative and fun and, (3) to reinforce the idea that learning is a family matter and life-long endeavour.

Although the BMES ERC partnering elementary school is only a mile away from the USC Health Sciences Campus, most of the students and their families have never formally visited the university. Therefore, the Family Science Discovery Day is hosted at USC offering the opportunity to introduce the students and their families to the university that is literally in their own back yard. In addition to participating in FSDD activities, the children and their families tour USC laboratories and meet with faculty and students. It is hoped that the FSDD events makes science a family affair and stimulates interest in science among students of all ages. Additionally, it is hoped that the local community considers the university a good neighbour.

Long-term Commitment and Sustainability

There are a myriad factors that influence student academic achievement and motivation and interest in science and engineering. Outreach efforts that are the products of university/K-12 partnerships have the potential to impact science literacy and students' perceptions of and attitudes toward science and engineering. Outreach programs take significant time to design and implement, however. They require a significant commitment from both the university and K-12 partners in regards to personnel, resources and funding. Many of the efforts that sustain outreach programs happen "behind the scenes" on issues such as preparing materials, setting up/breaking down hands-on labs, attending meetings, writing reports, and procuring funding. Relationship building, which is critical for the success of outreach programs, also takes a great deal of time and effort. Outreach partners need to relate to one another professionally, understand their counterparts' institutional cultures, and work as a team. Trust and mutual respect, key ingredient of a productive partnership, only come from experience by working with one another. For these reasons, efforts should be made to assure a long term commitment to university/K-12 partnerships.

The BMES ERC outreach programs are funded as part of a 10-year National Science Foundation grant. This extended tenure allows the university to enter into long-term partnerships with K-12 schools. School administrators and teachers appreciate the prolonged commitment the university is able to make. The BMES ERC/K-12 affiliation solicits input and feedback from university and K-12 stakeholders including administrators, teachers, students, counsellors and parents in the design and implementation of the outreach programs.

BMES ERC leadership made a decision early on to focus its efforts on a small number of schools. This allows for relationship building among the stakeholders and the outreach programs that can be evaluated by a stable cohort of participants. The reputation of the outreach programs is built upon its success in increasing student interest and literacy in science as well as through the advocacy by the scientists, engineers, teachers and students who are the backbone of the program. In order to sustain the BMES ERC outreach programs, financial support is sought from a variety of sources including state and federal grants, private foundations and the university itself.

3. Conclusion

The education of a nation’s youth, particularly in science and engineering, is critical for national security and international competitiveness. Scientifically literate individuals are better prepared to make informed decisions and are more likely to participate in and contribute to society. Educational research conducted at institutes of higher education have informed the development of K-16 pipelines and influenced education reform, including the development of pre-college math and science standards. In spite of the symbiotic interdependence between universities and K-12 establishments, both have institutional cultures that have developed in isolation of one another and are frequently misunderstood.

Education outreach programs that are products of university/K-12 partnerships are effective ways to facilitate closer ties between universities and K-12 institutions. The focus of outreach programs can be tailored to the needs of specific university/K-12 communities. Leveraging the human capital and specialized resources of the partners can result in collaborations that are mutually beneficial. Although the scope, goals, and objectives of outreach programs will depend on the particulars of the partnership, there are certain hallmarks of any robust and effective program. Cognizance of these features will help assure that university/K-12 collaborations are effective, long-term and sustainable. The development of a seamless transition of students from K-12 schools to college is critical in the preparation of a nations’ youth and the building of a scientifically literate workforce

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Introduction to Engineering: An Outreach Program Using the Mobile Studio Lab with Smart Lighting Systems

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Abstract

The continuous improvement of any nation depends on innovative education and research. The US continues to enjoy the global leadership role in developing and implementing cutting edge research. However, there are few underrepresented minority groups of researchers. The contribution of a diverse population of scientists and engineers is necessary to meet the world's competitive environment in technology and research for development. The smart lighting (for lighting and communications) outreach program is offered to introduce such under-represented groups to engineering. The mobile studio lab is used. It is a portable inexpensive lab that eliminates the need for several bulky classical expensive lab equipment. It consists of: (a) a Tablet- software that mimics instrumentation, (b) input/output I/O board with power supplies, for analog or digital experiments. (c) A bread board with the hardware set up, connected to the I/O board that is connected to the PC..

Keywords: *outreach, smart, lighting, mobile, studio*

1. Introduction

There is abundant information about how universities can improve the employability of their students especially through seminars and career fairs. American engineering universities concentrate on design principles and ability to use mathematics and science in solving everyday problems. It is well known that the following attributes are very important to engineering employers: practical application and understanding of theory to solve real world problems, innovation and creativity, ability to perform in teams, technical breath, ability to communicate (and some business skills). Research skills are important for technology and effective in participating in the global community, for developing appropriate infrastructures, and to promote sustainable development initiatives.

The Department of Electrical and Computer Engineering undergraduate curriculum has design components that involve minimal research. Our approach here is to introduce electrical engineering principles to under-represented groups from high schools who may be to future graduate students in the engineering profession. The department is a member of the Engineering Research Center group based in Renseller Polytechnic Institute in Troy, New York. We present here the smart lighting communication system and other as high school students' case studies in our outreach program.

Light emitting diodes (LEDs) are increasingly replacing fluorescent and incandescent lamps (electrically inefficient devices) as ordinary light sources. They are more efficient than fluorescent and incandescent lamps. LEDs operate at low dc voltages and take less current (about 20 volts dc and 1.5 Amps) as compared with conventional light sources that operate at 110 volts, 60 hertz ac, and around one amp or more. LEDs can also be used in smart lighting with several applications such as communications systems.

The continuous improvement or advanced standards of the citizens of any nation depends on continuous design and research. For many decades the US has continued to enjoy the global leadership role in developing and implementing cutting edge research [1] in universities and other agencies. However, there are few underrepresented minority groups engineers/scientists. The contribution of a diverse population of scientists and engineers is necessary to meet the world's competitive environment in technology and research for development. Presently, very low percentage of underrepresented groups participates in research. According to the US census bureau underrepresented groups will make about 48% of the workface by the year 2050 as opposed to 26% in 1995. There is always a need for more science, technology, engineering, and mathematics (STEM) workforce. At the moment STEM labor force is mostly white. However, there are talented underrepresented groups that need to be tapped and trained in the STEM system for research and improved technology. Advanced research provides significant innovative approach and overall impact to the progress of a nation.

This paper discusses how under-represented groups recruited from high schools can attend the Department's Smart Lighting Institute, an outreach summer (June through July) program. The aim is to motivate them to pursue STEM programs upon high school graduation to be undergraduate students and introduce them to how do design in an innovative way under the guidance of the engineering faculty. They learn about the overall impact of electrical and computer engineering principles with emphasis on smart lighting applications and its role in future living. They perform lots of hands on approach coupled with lectures relevant to the hands on approach. Other topics covered include communications (report writing, power point preparations, and oral presentation), team work for brainstorming and what to expect in the workplace. They learn soldering techniques and electrical instruments operation.

In STEM, communications such as, report writing, teamwork, oral presentations (power point and posters preparations) are important in showing a reader interpretation of data. They also learn about the specific aims of a project/experiment topics and the significance of the approach. Students with experience in STEM outreach programs will generally increase their expectations and success in college and improve their employability chances, The School of Engineering at Howard University has well established several research centers that focus on energy, material science and nanotechnology coupled with outreach summer programs for high school students. These programs are designed to motivate participants to pursue careers in the STEM areas.

2. Objectives of the Smart Lighting Institute Outreach Program

The engineering and science communities in the US are trying several methods of introducing high school students (especially under-represented groups) to STEM undergraduate education leading to cutting edge technology and also to motivate them become future researchers and educators. [2]. Howard University, located in the nation's capital, Washington DC, is one of the Historically Black Universities and Colleges (HBCUS) that offer advanced degrees including doctoral (PhDs) in electrical and computer engineering. Howard has a leadership role in the US and to the global community. There are several advanced research centers on campus with outreach programs. These research centers generally train graduate students in research. The research centers have summer outreach programs as part of community engagements. High school students are recruited to attend STEM programs such as the Smart Lighting Institute. Even though, the Department of Electrical and Computer Engineering recruits students every year, the intake is not enough to fill college studies positions. Our aim is to introduce high school students to engineering through lectures and hands-on techniques and also to motivate them to pursue undergraduate and graduate studies up to the doctoral levels as well as improving their employability skills. We recruit a handful of the top students for summer program under the leadership of the faculty and they work alongside with graduate students. They have lectures, hands on, seminars, design methods communications and technical writing.

Ability for high school students perform hands on and basic design and research will also improve college education skills leading to their employability skills in industry. According to [4] the chances of employability of a graduate student include communication skills, ability to function in an interdisciplinary team, integrity, and intellectual ability. The graduates must be able to apply theory to real world problems posed by industry customers. They must have understanding of theory, be creative and innovative. They must have ability to perform experiment and interpret data according to Accreditation Board for Engineering and Technology (ABET) program outcome assessment of courses requirements. They must possess life-long learning including technical breath. Business skills will be helpful.

The Department of Electrical and Computer Engineering at Howard University is a member of Engineering Research Center (ERC) group headquartered at the Rensallear Polytechnic Institute (RPI), Troy, New York. We form part of the Smart Lighting Research Group. A research in smart light emitting diodes (LEDs) is presented as a case study of research done by selected undergraduate trainee students at Howard University last summer. The outreach summer program emphasizes electrical and computer engineering and it is designed to provide an exciting, hands-on, introduction to engineering design using smart lighting (for example in communications) projects and using the mobile studio. Howard University is committed to providing an education environment that is accessible to all students. Each team writes a report and makes oral presentation (before invited guests-especially parents).

3. The Mobile Studio and Other Tools

In addition to several existing hands on and research tools (such as multi-meters, ammeter, voltmeters, and function generators) the mobile studio has recently been introduced in the department to aid in undergraduate work. The mobile studio is a portable lab that can be adapted to suit several hands on experience in several scientific and engineering disciplines. The mobile studio approach that combines hands on and lectures simultaneously. It is portable lab. The studio eliminates the need for several bulky classical lab equipment required for research. It consists of: (a) a Tablet-PC (lap top) with special software that mimics instrumentation and other features. (b) input/output I/O board that consists of dc power supplies, function generator and it can be used for analog or digital experiments. (c) A bread board that contains the hardware set up for the hands on approach. It is connected to the I/O board that is connected to the Tablet PC via a USB cable. It can be used for analog or digital systems. The high school students learn quickly how to use the mobile studio. They get excited about the results seen on the scope.

Additionally, traditional labs are equipped with bulky work benches and large expensive instruments and other equipment (such as large function generators , oscilloscopes and power supplies) sources that consume a lot of electric energy for operation at this time of the world's crisis and dwindling energy sources. Due to limitation of space and bulky equipment, students work areas are limited and thus they forced to work in overcrowded groups. It contributes to a few students in a group who can actually participate in performing hands on the tasks required for the lab under investigation. The rest only act as recorders. They hardly participate or contribute to the success of the lab.

Thus the usual old fashioned laboratory setup (Figure 1) that includes separate oscilloscope, multi-meter, power supply, function generator and others (digital equipment) has been replaced with the 'portable' mobile studio setup (Figure 2) that consists of a breadboard. It is so small it can fit in a backpack and carried home for more explorations of hands on. The package shown in figure 1 allows individual participation since it occupies a small space and it is less expensive compared with bulky lab expensive lab equipment. It also consumes much less electric energy compared with the traditional lab equipment.

Figure 1. Old Fashion Traditional Lab Concept-Bulky

Figure 2. Compact Mobile Studio- Smart Lighti
Presentation

Figure 3 also shows the I/O board instrumentation panel displayed on the tablet PC screen. The I/O board emulates a function generator, oscilloscope, voltmeter, Spectrum analyzer, ±4V DC power supply and is capable of digital operations. Thus the board output dc power supply lies within the range of -4V to +4V, thus all the hands on experiments need to be scaled down to the operating dc voltage range.

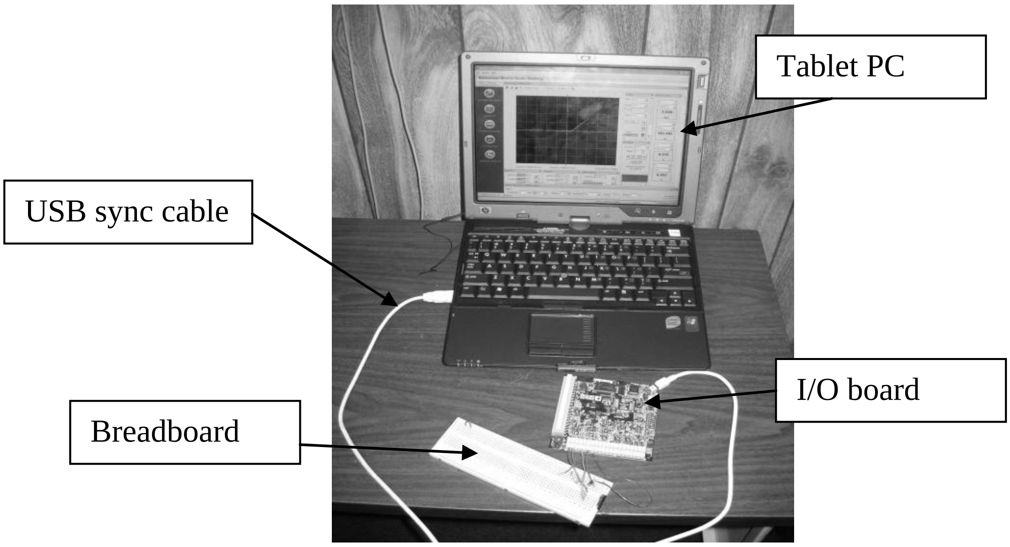

Figure 3. Mobile Studio Station

The mobile studio concept originates from Rensselaer Polytechnic Institute, RPI, Troy, New York,, the originator of the mobile studio concept. Thus due to flexibility of the mobile studio, the approach was extend to electronics courses at the junior level. Now, in addition to above course, the studio is being used in digital, circuits, and electronics courses, as well as in senior capstone design projects. It has also be introduce in freshman introduction to electrical and computer engineering courses, and high school outreach programs.

The students obtain experience in experimentation, measurements also obtain direct plots instead of using paper and pencil for plot later when the experiment is completed. Instant plots allow for instant correction just in case of a wrong data set. The Mobile studio is used in several fields (civil and mechanical engineering) using transducers to convert other signals to electrical signals to enable the studio to interpret data.

4. Smart Lighting Institute Activities

The Smart Lighting Institute outreach high school program runs in summer months for 5 or 6 weeks. Participants total an the average of 20 students generally selected form 9-12 graders with equal number of males and females. The program staff consists of 3 faculty members, and 3 mentors (ranging from undergrads to graduates students). Monday-Friday, 9.00 am – 5.00 pm. The function of the mentors includes assisting the faculty in instructions, controlling the students' behavior, grading students' assignments, a lab technician who introduces them to soldering skills and laboratory safety. 2013 is the fifth year of running the program. The Smart Lighting Summer Program, sponsored by the National Science Foundation and administered by the Department of Electrical and Computer Engineering at Howard University, was held during the period June 17 – July 26, 2013. A total of eighteen high school students enrolled in grades 9 to 12 were in attendance. The program was divided into two modules:
Module 1: Computer Networks, (computer engineering instructor and mentors)
Module 2: Smart Lighting. (electrical engineering instructor and mentors)

The following section shows the weekly activities that were accomplished and recommendations for improving the program for the upcoming years.

4.1 Summary

The Smart Lighting program was divided into two (2) modules: Computer Networking and Smart Lighting.
Module I: Computer networking with Juniper routers and switches, JUNOS operating system, students were taught commands using that system. Troubleshooting techniques using commands such as “ping” and “trace route”.. A design project- how to connect routers and communicate to each router within the network.

Module II: Basic electrical concepts, circuits, devices, resistors color code, semiconductors, diodes, photo, light emitting diodes. hands-on activities (working with breadboards, soldering, putting together), building a siren kit, AM radio as well as working with transceivers (light communications), design projects.

Other activities: putting together a Rubik’s cube, Frisbee session, demonstration of robots, campus tour, nanotechnology lab tour, cyber security session by the Federal Bureau of Investigation, and a Jeopardy game added variety to the program. Weekly oral team presentations, summary of what they learned each week.
The program ends with a final presentation to parents and a closing ceremony where the students and mentors are given certificates for their participation.

4.2 Documentation of Activities

The folder was shared with all staff who worked on the program. The material included daily notes, homework assignments and solutions, quizzes and solutions, labs, hands-on activities, other training material, student presentations, student reports, student grades, and photos.

***Week 1:* June 17 to 21, 2013**
Monday: Orientation, introduction of professors, staff, and mentors (teaching assistants). Outline of behavior rules and regulations, the participants expectations of the program given
Tuesday: Module I: Computer networks, lectures, hands-on activities, homework assignments, and quizzes. An introduction and overview of the program- numbering systems (binary, decimal, octal, hexadecimal), bits, ASCII code, conversion between numbering systems, IP (internet protocol), and IP address
Wednesday: Continuation of IP addressing systems.
Thursday: Lectures, hands-on activities and video presentations. Topics-cabling RJ45, WBT, and Introduction to Juniper & JUNOS operating systems. The hands-on activity- making ends on CAT 5 cables, registration on the Juniper website in order to access training modules.
Friday. Preparation for presentations, tips on how to make power point presentations and public speaking were given by the TA’s in the morning., team oral presentations and grading, afternoon.
A Rubik’s cube puzzle was also given to the students fun brain teaser activity and junos training soft copy.

***Week 2:* June 24 to 28**
Lectures, hands-on activities, homework assignments, and quizzes.
Monday and Tuesday, the JUNOS operating system and user interface options was completed. This included lectures and hands-on activities.
Wednesday morning, a lab, afternoon, the students practiced oral presentations.
Thursday, the students completed their individual sections for Week 2 presentations, commenced Part 1 labs and, introduction of the department chair, Dr. Mohamed Chouikha, program director
Friday: Oral presentation, in the morning, the students prepare for team presentation power point slides. In the afternoon, the teams presentations. As usual, mentors grade presentations. The students get Frisbee tokens to be used during breaks.

***Week 3:* July 1 to 3 and July 5**
Lectures, hands-on activities and a demonstration. Homework assignments and quizzes given each day.
Monday: the design project introduced and the students began working in teams on their projects. For the projects each team was asked to design a computer network system that involves Juniper Router (series J2320) to provide full connectivity from a team’s network to every other team’s network. The design was considered a success if each team could “ping” from their router, and “trace route” from their router to each IP address in the network.
Tuesday: the activity of making serial connections and presentation preparation presentation

.The university was closed on Thursday due to the July 4 public holiday. No classes On Friday, the students completed hands-on activities that involved “ping” and “trace route” from each team’s router to the opposite router’s laptop. The students were told to save their results and submit it in a draft of their design project report. A graduate student gave a demonstration of robots in the afternoon.

Week 4: **July 8 to 12**
Module II: Smart Lighting. The activities are combination of lectures, labs, hands-on activities, video presentations and assignments.
Monday morning, introduction of concepts of electricity and electrical and computer engineering. assignment for students to research and write about international system of units (SI), types of resistors, types of inductors (magnets), types of capacitors, and applications of these devices.
Tuesday, Lab Safety, Lab#1 – current, voltage and resistance, Ohm’s Law, resistor color coding, breadboards, measuring current, voltage and resistance, DC power supplies, and voltage and current division. In the afternoon, lab reports writing.
Wednesday: A lecture on circuit elements, morning, while hands-on Activity #1- identifying resistors using color code and by using a portable multi-meter as well as video presentations on “How breadboards work?” and “Introductions to breadboards, parts 1 and 2”. Physics fun facts were also shown.
Thursday: Campus tour, morning, followed by hands-on Activity #2 – An introduction to LEDs. The activity involved identifying resistors using color code and setting up a simple circuit with a 9V battery, resistors and LED’s on a breadboard. In the afternoon, introduction of Mobile Studio a laboratory tool to be used in all hands on work, demonstration with the studio while the students followed.
Friday: Presentation #4 preparation, oral presentation, afternoon. grading by mentors and others - format of the presentation, lessons learned for the week such as electricity, lab safety, lab equipment, breadboard usage, mobile studio, IC chips and a Physics Fun Fact.

Week 5: **July 15 to 19**
Mostly hands-on activities interspersed with a tour, seminar and report writing sessions
Monday: soldering. videos on soldering techniques, soldering demonstration. Hands-on activity#3 - Introduction on Soldering , afternoon. light session of the game Jeopardy.
Tuesday: completion of hands-on activity, hands on power LED’s, report writing, afternoon.
Wednesday: Cyber security seminar facilitated by Federal Bureau of Investigation (FBI). Representative. General Cyber security issues such as banking, identity theft, and social networks were discussed, hands-on activity building of European Siren Kit by soldering, report writing session. The Siren kits worked and students enjoyed this exercise.
Thursday: morning completion of Cyber security and Siren Kit reports, preparation fore Week 5 presentation, afternoon. Introduction of design projects, students began their background reading/research.

Friday, students design projects in the morning and delivered their presentations in the afternoon. Each group was assigned separate projects. (Mobile studio is used in all projects and hands on labs).

- Team 1: Acoustic Heart Monitor
- Team 2: Signaling Using Light: Modulating Analog Signals
- Team 3: PCB Assembly: Building a Visible Light Transceiver
- Team 4: Driving the Smart Light Transceiver
- Team 5. AM Radio

Week 6: **July 22 to 26**
Completion of team design projects, work on their final presentations, and final individual report writing.
Monday, Tuesday: Smart lighting design projects completed. Two students who were absent during the previous week were given a separate project to build an AM transmitter. Nanotechnology research center tour
Wednesday: computer network design project, final presentation preparation.
Thursday: The final presentation and closing ceremony in the morning. The parents were invited and they gave positive feedback about the program. The students and mentors were presented with certificates.
On Friday: Completion and submission individual final reports.

4.3 Discussions: Lessons Learnt

Overall, the program was completed satisfactorily with some obstacles along the way. The following sections include the strengths and weaknesses that were observed in the program.

Strong points

- Discipline was maintained to ensure that the rules and regulations were abided by.
- The hands-on activities were preferred by the students
- The lessons breaks, games Rubik's cube, Frisbee sessions, Jeopardy game were viewed as positive.
- Once the students had activities to do, it was observed that the tendency was for them to give less trouble.
- After activities for both modules once planned eventually ran smoothly.

Weak points

- The daily activities were not planned beforehand.
- It was observed that too many lectures may have caused some of the students to sleep in class. They were more alert during the hand-on sessions.
- The grade (grades 9 -12) of the students was too wide causing some students to be left behind in instructions.

4.4 Smart Lighting Program Assessment:

The assessment was based on several areas(with 15 students sample) responses as listed below.
Notation: SD = Strongly Disagree, D = Disagree, N = Neutral, A = Agree, SA = Strongly Agree

a. I gained new insights and practical skills from this program: A = 47%, SA = 33%
b. The equipment were sufficient and operated efficiently: A = 40 %, SA = 53%
c. Homework and quizzes reinforced what I learnt: A = 53%, SA = 27%
d. The hands on labs reinforced what I learnt: A = 53%, SA = 27%
e. The weekly oral presentations reinforced what I learnt: N = 40%, A = 27%, SA = 27%
f. I feel more confident working with teams in summer program: N = 33%, A = 27%, SA = 27%

Describe what you learnt in the program: Response – computer networking, IP address, routing, electric systems, electronics, team work, smart lighting systems experience, use of mobile studio for hands on projects, soldering, report writing and oral presentations. Describe what you wanted to learn but not taught: Response – programming and web design, more projects in smart lighting.

We can see from the assessment that the participants had a good time. They gained engineering and team work experiences in the short time duration Smart lighting outreach program, and they would recommend their friends for future program participation. The Smart Lighting Program (in its fifth year) at Howard University is sponsored by the National Science Foundation (SF) through Rensalear Politechnique Institute (RPI). At the end of the program, a report is sent to RPI. The overall feedback has been highly satisfactory and they would like to see more students participate in future.

4.5 Recommendations

- Plan each day's activities prior to commencing the program. This plan should include lecture notes, hands-on activities, homework, quizzes, and other activities and should be distributed to all staff working on the program. All professors should agree sign-off on the plan for the program modules prior to the beginning of the program in order to avoid discrepancies and confusion.
- Have more ice-breaking activities and enroll a more narrow age range of (10-12 grades) students.
- Keep the record of the soft copy of the TA's compilation of the Smart Lighting program on file so that it can be referenced for the next year.

5. Conclusion

Overall, the program was completed and went satisfactorily. The students learned about computer networking using juniper equipment and smart lighting concepts. They were exposed to university life and the engineering discipline. Some good friendships were made, and I believe the students left more educated and confident. Our aim is to introduce under-represented high school students to STEM activities to motivate them to purse STEM areas in their college education and make contribution to the respective profession. In research and practice , we are very positive this will attract these young minds to pursue college studies and make a contribution to engineering research and cutting edge technology and education profession and sustain the environment. The experience will also improve their employability stills. The introduction of the mobile studio as a teaching or research tools has helped reducing bulky lab equipment. It has also increased the awareness of engineering and research in high school students who participate in the department's summer outreach program. The assessment off the program receives high response and in favor of quality work.

6. Acknowledgements

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Exploring the "how of engineering competence:" Using service-learning projects in an engineering communications course to facilitate the professional practice of undergraduate engineering students.

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Abstract

Enabling engineering graduates' efficacious transition from the classroom to the workplace has long been an important aim for engineering educators. Our study explores the "how of engineering competence" in a single engineering communications course in an attempt to generate a theory of competency formation. We employed two research methodologies: action research and grounded theory. The results suggest that students can be taught to identify and claim their competencies. In addition, we have introduced new concepts – activities/practices, skills, abilities, and competencies – and with them new ways of thinking about the process of competency formation. Our short-term goal is to enable the continued investigations of those competencies and their development. Our long-term goal is to encourage the redesign of engineering curricula in ways that both benefit from those investigations and better prepare students for professional practice.

Keywords: *Professional Practice, Competency, Grounded Theory.*

1. Introduction

It has become a constant refrain that "engineering education . . . falls short of the goal of adequately preparing students for professional practice." [1] Of course, we have our customary and exculpatory responses. First, a "university education should not be constrained by the training requirements of a particular profession." [2] Or second, it is impossible for those designing and implementing engineering curricula "to keep pace with the rapid technological developments . . . [quite apart from the developments of new knowledge] that are typical of the expanding responsibilities of the profession." [1] And, third, "students . . . [are] learning about engineering" even though some may "fail to integrate the knowledge that they are gaining . . . into a more complex, complete understanding of what it means to be an engineer." [3]

While each of the above responses to falling short is *both* undeniably *and* only partially true; there is exciting new research that suggests perhaps a fourth less exculpatory and more useful response. Walther et al., recommend that we pay attention to "Accidental Competency formation." [1] Accidental Competency formation refers to that "complex system where a range of influences outside the realm of explicit instruction contribute to the development of students as professional engineers." [1] As a simple illustration, they relate the "tensions and pressures associated with [a] final exam" to preparing students "with the skills required to meet critical deadlines" as professional engineers. [1] What is exciting about their research is that they suggest that there may be both a *fortuitous*, i.e., "accidental," formation of competencies that is still potentially quite *helpful* for students in making the transition to professional practice and in their performance as professionals. In their study involving sixty-eight engineering students across four different countries, they identify seven "competency clusters" – "Flexibility, Interaction, Plan, Professional Realities, Self, Social Context and Technical." [1] They claim that "acknowledging these effects [or the seven competency clusters] and providing an evidenced-based foundation for their investigation and integration into teaching practice . . . creates the opportunity for engineering education to achieve some of the broader goals defined in educational outcomes." [1] In other words, if engineering educators can find an efficient, by virtue of it being indirect and "low-cost," yet an effective means for preparing students for professional practice, then certainly we should consider such when designing curricula. Walther et al., advocate that the best way to realize both that efficiency and effectiveness is for those same engineering educators to pay attention to the "how of engineering competence" or the implicit process as well as (and perhaps even more than) the "what of engineering competence" or the explicit content and goals. [1]

In our study, still very much a work in progress, that is exactly what we have done and a little bit more. We have paid attention to the how of engineering competence – to the process. The little bit more is finding a way to identify and define the key concepts related to engineering or engineering-like performance and begin, through exploring the relationships of those concepts to each other, to articulate a theory of competency formation.

Like the authors cited above, Collin believes, as do we, that "there is a clear need for more effective integration between education and working life." [4] And, we agree with Walther et al., that much more can and should be done to incorporate the how of engineering competence along with the what in order to facilitate that effective integration. [1] However, we also believe that we must acknowledge up-front the complexity of such an undertaking. It will require far more than a simple *mixing*. As Trevelyan above suggests, students "encounter a very different world when they start working." [2]

2. The different worlds of the classroom and the workplace

Engineering educators have been aware of these different worlds, namely the world of the classroom and that of the workplace, for quite some time. In response, they have introduced "pedagogies of engagement" [5] that include inquiry-based learning, problem-based learning, and project-based learning. They have introduced service-learning, design thinking and interdisciplinary project teams and more, all with the aim not only of enhancing student learning, but also of enabling a less difficult transition to professional practice.

Perhaps no one is more aware of the differences between the two worlds than those of us tasked with teaching technical communications in schools and colleges of engineering. As Marie C. Paretti states, "Proposals, progress reports, design documents, and similar texts represent engineers' work to those empowered to act on it, and thus they serve critical functions in the ongoing work of an organization." [6] However, when those same documents are taught in courses and classrooms, the readers of and responders to those documents are not themselves practicing engineers, managers of engineers, clients or even stakeholders in any way. Consequently, the genuine communicative purposes for which they were/are created is lost. Paretti goes on to state that "in the classroom, communication assignments [like those above] are easily divorced from functionality; faculty [for example], unlike managers, do not need reports and presentations to make technical decisions; they already know more than their students, so the texts 'function' primarily (often only) as a means to evaluate student knowledge and performance." [6] As a result, those very students, by virtue of them *being students*, are often asked to communicate "the wrong thing, for the wrong reason, to the wrong person, who evaluates it on the wrong basis." [7]

In "Worlds Apart: Acting and Writing in Academic and Workplace Contexts" Dias et al., describe what exactly the contrasting characteristics of those different worlds are. [8] Those contrasting characteristics drawn from their research are summarized in Figure 1 below.

In response, they suggest that "If there is one major, seemingly obvious way in which educational courses might prepare people better for the demands of writing [or communicating] at work, it is through constituting the class as a working group with some degree of complexity, continuity, and interdependency of joint activity." [8] Paretti too calls for "learner-centered classrooms" where the

In the classroom:	**In the workplace:**
Aim is Epistemic (learning)	Aim is Instrumental (doing rather than learning)
Context is Designed (static)	Context is Improvisatory (dynamic rather than static)
Roles are Established (identity is predetermined)	Roles are Multiple/Variable (identity to-be-determined)
Agency is Facilitated Performance (demonstrational)	Agency is Participatory (contributory)
Frame is a Fixed Structure (consistent-across-time)	Frame is Indeterminate (contingent)

Figure 1: Contrasting Characteristics of the Classroom and the Workplace.

approach not only offers students "the opportunity to develop richer, more complex understandings of the material at hand," but also provides "a more authentic opportunity for students to engage meaningfully in

communicative action." [6] Similarly, Trevelyan, troubled by "the misunderstandings about engineering practice among novices" calls for engineering educators to "design authentic learning tasks," tasks that might help students to develop those "attributes and thinking styles more appropriate for industrial practice." [2]

As the glaring differences in the above contrasting characteristics reveal, we can, indeed, should never hope or even attempt in the classroom to replicate the workplace. Classrooms are the way they are because they are **not** workplaces. Conversely, workplaces are the way they are because they are **not** classrooms. Aim, context, roles, agency, and frame are all different as they should be. However, if we can design more authentic tasks, then we can at least begin to understand the how of engineering competence or the process and through that understanding generate a theory (or the outlines of a theory) of competency formation. Perhaps if we can replicate at least that process and, at the same time, learn more about competency formation as it happens in both the classroom and the workplace, then we may make the classroom to workplace transition less difficult.

3. Course description and approach

The course I teach is entitled, *Engineering Communications*, and John, my co-author, was a student in that course during the spring semester of 2013. It is a service-learning course in which designated student teams of 3-5 students identify a *need* within a particular *community*. That need often exists within the academic community of Cornell University. However, the needs and communities are not restricted beforehand. The student teams must also identify a *client* associated with that need. And finally, they must envision, with the help of their client, one or more *deliverables* that will be provided to the client and that the client will *value* by the end of the semester. So, need, community, client, deliverable, and value are all focal features of students' service-learning experience.

Student teams are asked to produce and share the traditional engineering documents associated with projects like theirs: a proposal, a timeline or work schedule, a progress report, and a final report. They share these documents with both me and their client. Indeed, I ask that the clients approve the projects and their progress by signing copies of both the proposal and the progress report. Sometimes the final report is the deliverable. Sometimes it or some other documents similar to a final report accompany a different final deliverable or deliverables. In addition, there are a number of other documents or communication genres that the students use, indeed find necessary to use in the completion of their projects. Emails, meetings, presentations, and any number of visuals, e.g., renditions, illustrations, diagrams, graphs, tables, charts and so on, typically are also required. There may be (almost always are) documents or genres specific to the particular project that are produced, e.g., documentation related to software products and instructional manuals pertaining to their use. Finally, I ask that the student teams collect *all the above documents/genres and more* (because there are several that I ask them to perform as part of their participation in the course, e.g., competency statements, learning letters) into an e-portfolio software entitled Mahara™. This e-portfolio is due at the end of the semester.

Tsang identifies two "key concepts of service-learning:" reflection and reciprocity. [9] Clearly, reciprocity understood as "the needs of the community, as determined by its members, define what the service tasks will be" is apparent in our above, albeit brief, description of course requirements. [10]

Reflection understood as "a reflective component explicitly designed to foster learning and development" is perhaps a bit less apparent. [10] My goals in designing opportunities to reflect in the course are twofold. First, I want students to focus on the how of engineering competence, making competency formation anything but accidental. And, second I want to create opportunities for individual students and student teams to make sense of, indeed, to represent the competencies that they claim through a professional e-portfolio activity. Since the focus of this paper is competency and competency formation, we will describe briefly that reflective component related to competency formation as it is experienced by the students and their teams.

3.1. Reflecting on Competencies

There is a vast literature promoting the importance of reflection or meta-cognitive awareness. [11] In other words, it is important that students not only learn, but also be aware of what and how they are learning. As a consequence, I devised a four-step sequence of opportunities for students to learn, and then to reflect on that learning in terms of what that learning enables them to do.

The sequence begins with a visit to the campus art museum. I suggest that as professionals they will need to identify and claim what they can do. I hand out a number of "competency statements." My purpose is to provide students with samples of the genre. During their visit to the museum, students are asked to study, briefly, a pre-selected work of art, and then to present their response to that work to the rest of the class. The art museum staff assist them by first modelling how one might go about attending and responding to a work of art. Then, each student team is asked to study a particular piece, and then present their responses to the other teams. When all the teams have presented, I ask them to tell me "what they can do" based on the experience they have just had. In other words, I ask them to claim a competency.

The second step is to ask students during class time to identify and claim 4-6 competencies that they have developed through participating in their service-learning projects. This happens once they are well underway in their projects. They do this as a team, so that they can learn from each other. I ask as well that they identify the actions/practices related to those competencies. In addition, I distribute again the sample competency statements and circulate in the classroom to answer any questions and/or offer help formulating the statements. After 20 or so minutes, I ask students to "turn that list of competencies and related list of practices" into a "resume item." Further, I tell them that they will be asked to generate competency statements again at the end of the semester when they construct their e-portfolios.

Toward the end of the semester, and nearing the completion of their projects, I ask students to perform the third step in the sequence – an in-class reflection on their competencies. I distribute a handout that introduces them to James Trevelyan, and his model of what engineers do. [14] His model delineates engineering practice into six phases reproduced in Figure 2 below. Trevelyan refers to this model of engineering practice as a "human social performance." [12]

I ask that in their teams they identify the genres that they have enabled them to perform each of the above phases. Then, I ask them to identify the competencies (again) based on their own participation so far in their projects. We spend the entire class-time on this exercise. And students typically do a great job of responding to both of my requests. Next, I ask them – as individuals – to identify any competencies that perhaps their team has not identified, yet that they think is particularly relevant to them as an individual. Finally, I ask that each team list their competencies on the whiteboards on each of the walls in the classroom and present their competencies to the rest of the class.

1. **Building relationships**, e.g. developing channels for interaction, acknowledging project participants (participants in addition to "clients"), gaining participants trust, confidence and continuing engagement and involvement.
2. **Analyzing problems/needs**, e.g. establishing (often negotiating) problems/needs, proposing preliminary solutions, shaping participant expectations, initial planning, previewing enactment and outcomes.
3. **Developing solutions**, e.g. collecting data, creating possible solutions, testing and evaluating those solutions, diagnosing deficiencies and then re-creating, re-testing, re-evaluating alternative solutions.

Trevelyan suggests that these first three phases are typically recursive. He refers to these first three phases as "front-end engineering." The next three phases, he calls "project execution."

4. **Launching a project**, e.g. deciding to proceed with a project, producing final (detailed) plans, designs, specifications, organizing and marshalling people and resources for enactment (i.e. producing, constructing, commissioning, operating, maintaining).
5. **Coordinating, monitoring and evaluating a project**, e.g. regulating work flow and participation and contributions, adapting to circumstances, maintaining engagement and involvement by various participants.
6. **Producing deliverables**, e.g. coordinating project conclusion in concert with providing outcomes, assessing the need for follow-up and/or review, preparing for remediation, gauging participant satisfaction.

Figure 2: Engineering as "Human Social Performance." Adapted from Trevelyan (2010).

The fourth and final step in the sequence is the e-portfolio or Mahara™. It represents the culmination of the first three steps in two ways. First, the e-portfolio is a representation, really more of a *presentation*, of their entire body of work on their service-learning projects and for the *Engineering Communications* course. Everything associated with the course ranging from their individual responses to the questions at the end of the chapters of required reading to the actual deliverables provided to their clients should appear in the e-portfolio. Metaphorically speaking, it "tells the story" of their service-learning project, of their learning and offers a presentation of what they can do. Second, the e-portfolio as that presentation is itself a professional document that performs an action or, actually, a number of actions. It is context-bound. It requires "design" or a structure for performing those actions within that context. And it creates identity, in this case both a team identity and individual identities. These are the four fundamental concepts related to communication that students have long ago tired of me seemingly endlessly repeating.

The students also must present their competency statements as part of that e-portfolio. Sometimes they are the same as they were for step three and sometimes they are different. However, most importantly, those competency statements now have an "objective correlative" in the e-portfolio—something that not only names and claims those competencies, but "shows" (rather than merely describes) those competencies named and claimed.

4. Methodological Frameworks

We employed two research methodologies during the conduct of this study. The first was an action research methodology in which I introduced the concept of competence and then led students through a series of learning/reflective experiences that provided scaffolding for learning how to identify and claim the competencies resulting from their service-learning projects. That scaffolding was described above. According to Case and Light, "[t]he aims and benefits of action research are [the] strategic improvement of practice." [13] In the particular case of *Engineering Communications*, this was true in both a narrow and broad sense. I did, in fact, want to introduce students to an effective way for them to *see what they were learning and doing*, e.g., solving a problem, serving a need, creating value and performing all the actions/practices, including communication, necessary to solve that problem, serve that need, create that value. That was the narrow sense. I also wanted them to *understand the implications that this learning and doing might have* for them moving forward into their professional lives. That is, if they developed an approach for identifying and claiming competencies, a better understanding of the how of engineering competence; then perhaps they could use that approach in their careers, enabling the actualization of what we too casually refer to as life-long learning. That was the broad sense. My co-author's role evolved over the semester into that of a "participant" typical of "emancipatory action research" as he became a "participant-as-researcher [in order] to critically explore the effectiveness of practice." [13]

The second was a "grounded theory" methodology. [14] [15] As stated above, each team was required at the end of the semester to create an e-portfolio presentation of their service-learning project and of their learning experience. Consequently, these e-portfolios became rich sources of data related to their newly-formed and situationally-dependent competencies. [16] The authors employed a process of open coding, moving toward axial coding, and then theoretical sampling of the documents included in the student teams' portfolios. Since ours is still a work in progress, we have not yet reached the endpoint of "theoretical saturation." [13] Similar to the action research methodology, there was both an immediate and a more continuing reason for employing grounded theory. The immediate reason was to be able to look at the e-portfolios as data relating to the success or not of the action research. Could we find in the presentations of the students' learning experiences evidence of them *seeing and understanding* their own competencies? The more enduring reason was: Could we use that data "systematically gathered and analysed" to begin "developing a theory . . .[of competency formation]." [13]

The results of both research projects suggest that students can be taught to identify and claim their competencies. The results also suggest that students can present evidence of those competencies in ways that allow them to be specific about "what it means to be an engineer." [3] Because of our limitations of space, we will not present those results. However, in what follows we will present the outlines of a theory concerning how competencies are formed – something akin to *the how of engineering competence*.

5. Results

According to Strauss and Corbin, "a grounded theory is one that is inductively derived . . . . [t]hat is, it is discovered, developed, and provisionally verified through systematic data collection and the analysis of [that] data." [14] Based on this understanding of grounded theory, our research question was: Through the various ways of collecting and analysing data, can we discover, develop, and provisionally verify a grounded theory of competency formation? Said somewhat more descriptively, can we look at student team e-portfolios and from those e-portfolios *discover* "concepts," or labels for "discrete happenings [and/or] events" relevant to engineering competence? [14] Can we then "group those concepts" together, each related to the other, in order to *develop* a "category" or "theme" in ways that would at least offer insight into or perhaps *provisionally verify* the process of competency formation? [15] These questions focused our research on a single "educational influence" represented in Walther's "contextual model of competence formation," that of "learning activities." [1] Our rationale was that if engineering educators are to pay attention, as Walther et al., suggest, to the how of engineering competence; then they must know more about what specifically to pay attention to.

If we are interested in developing a grounded theory of competency formation, then it stands to reason that competency is a most important concept. As stated earlier, Walther et al., offers us several examples of competency clusters. [1] However, each of these clusters seems to be as vague and unhelpfully non-descript as are the ABET (Accreditation Board for Engineering and Technology) outcome statements. For example, what does the "ability to communicate effectively" actually mean? Similarly, what does "interaction" mean? [1] However, Passow has offered us some help. [17] He defines competency as "the knowledge, skills, abilities . . . and other characteristics that enable a person [or persons] to perform skilfully (i.e., to make sound decisions and take effective action) in complex and uncertain situations such as professional work, civic engagement, and personal life." [19] Some of the important concepts suggested by his definition are action or actions/practices, skills, abilities, situation, performance and, of course, competency. So, what might each of these concepts mean? Also, what does our coding suggest that the relationships of each of these concepts are to one another?

Action or actions/practices are the simple *things we do*. Actions/practices are the ubiquitous, often mundane behavioural stuff of everyday life. Because they are so, it is easy to ignore them. Just like the rest of us, the students in their portfolios often ignored actions/practices, the behavioural stuff of their projects. Indeed, it is hard to recount *all* the things we do when we are engaged in a project. So, how did we know that actions/practices were real to them, were a genuine part of their experience? In response to the first reflective exercise at the art museum, students often conflated actions/practices with what they might later come to think of as skills, abilities, or competencies. To illustrate the extremes, they might confuse "observe" with "appreciate art." This was a response that disappeared through the four-step sequence as they developed a more discriminating way of reflecting on their experience. Even though some may have found them difficult to separate initially, the students gradually became aware that skills, abilities, and competencies had "properties" and "dimensions" that made them different from actions/practices. [17] In fact, as they progressed through the semester, they became increasing able to not only discriminate, but also to cull actions/practices from their competency statements.

Skill or skills are those actions/practices that can be *improved through practice* and are *effective to purpose*. Being able to improve or recognizing a need to improve through practice is the property that distinguishes skills from actions/practices. Through the semester, students increasingly identified specific skills that they needed to and eventually did improve. In addition, they used the dimension of effective to purpose as a way to gauge or measure their improvement. In response to the third step in the reflective sequence, the student teams found it quite easy to identify these skills. Indeed, they used the term "skills" as a marker to differentiate them from actions/practices. For example, one of the student teams was creating a "wireframe mock-up" design for the website celebrating the Sesquicentennial of Cornell University. Their client was University Communications. They reported developing "Balsamiq and Photoshop skills" necessary for producing their final design product. Another team was interested in exploring and implementing a social media product that might facilitate the interaction of women with other women in engineering. As part of their preliminary research to determine which social media product might be best suited to encourage this interaction; they created an online survey, distributed that survey, then analysed the results. They identified each as a skill.

Ability or abilities refers to that *collection of actions/practices become skills now coordinated in and through their enactment*. In other words, an ability is a particular collection of relevant skills, in a sense, an aggregate of related skills necessary for the performance of some component of the project. Referring again to the project involving the selection of an appropriate social media; creating, distributing, analysing a survey are all relevant and related skills associated with the ability to do a kind of market research. What distinguishes abilities from skills is that, whereas skills are improved through practice, abilities are developed, indeed realized through the coordination and application of established skills. There can be no abilities without the appropriate "skill sets." In effect, those skill sets are a kind of prerequisite.

Before we discuss competencies, it might be helpful to look at Figure 3 below. In Figure 3, The Pyramidal Nature of Competency Formation, we have introduced four of the key concepts resulting from our analysis of the student team e-portfolios. We have also attempted to represent the relationship of those concepts to one another. Activities/practices combine to become skills, skills combine to become abilities, and abilities combine to become competencies. The arrows on the right suggest this movement. When this combining occurs, for example, skills become different than activities/practices. They develop new properties and dimensions. The same is true for abilities and competencies. As a result, each "upper level" is potentially more empowering than the "lower level." In particular, each is more empowering because it is more generally applicable to a greater variety of situations and in a broader range of performances.

Notice the arrows on the left. In both the classroom and in the workplace, new situations arise that require new kinds of performances. Our initial inclination in those situations requiring new performances is to rely on already formed competencies, which also means already formed abilities and skills. Often, the "already formed" are sufficient. However, in some cases, they are not. In those cases, students and professional practitioners must move down the pyramid, assessing at each level if the abilities, and if not then the skills, and if not then the activities/practices exist as part of their available experiential repertoire. If they do not at all of the levels, then the competency formation process starts all over again with activities/practices, the improvement of those activities/practices through practice to become skills, and the coordination of those skills to become abilities.

So, what are competencies? The competencies that my students claimed in their e-portfolios are much the same as those that Walther et al., offer or that ABET articulates as outcomes. As one might expect from a course entitled *Engineering Communications*, there were a number of competency claims relating to effective communication. Yet, they typically went further, they specifically included the *abilities* to perform certain kinds of communication, e.g., presentations, establish and maintain collaborative

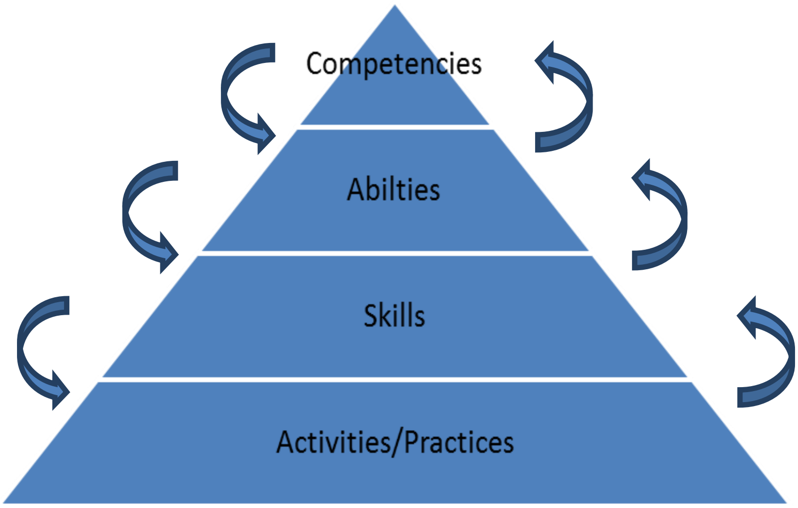

Figure 3: Pyramidal Nature of Competency Formation.

relationships with clients, prepare user documents for training. In addition, they mentioned the *skills* related to those kinds of communication. For example, with presentations, they included those skills related to designing slides, creating and projecting a professional persona, and facilitating audience engagement. There were other competencies. Project management was one. The abilities that they mentioned were resource assessment, planning, monitoring, and evaluating progress. The skills were creating time and task schedules, establishing feedback loops both among the team members and with clients, adjusting schedules, even deliverables based on project contingencies. Our point is that while individual students and student teams may not have represented their experience using the concepts activities/practices, skills, abilities, and competencies, they nonetheless were aware of these concepts and their relations to one another. Further, they were aware of the how competencies came about and how to develop new competencies when necessary.

6. Conclusion

We began this paper highlighting a few of the responses to the perceived need for more effective integration between engineering education and working life. The proposed solution, as many have suggested, is to make engineering education more "work-life-like." After all, the best way to enable the transfer of learning from the classroom to professional practice in the workplace is to lessen the distance between the two. We have challenged this solution. Classrooms are different than workplaces and will continue to be so (whether we like it or not). However, we have suggested an alternative solution. Perhaps if we can provide students with authentic learning tasks, then help them to attend to the how of engineering competence, to the process of competency formation. Maybe the awareness of the process will transfer. The competencies themselves will always be changing, but the process of forming those competencies will not. In addition, we have introduced new concepts – activities/practices, skills, abilities, and competencies – and with them new ways of thinking about competency formation. Perhaps such a theory of competency formation, grounded in student teams' representation of their semester's experience, will suggest new possibilities for further investigations, and even new ways of designing engineering education curricula.

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Presenter: The paper is presented by Rick Evans

Social Media and Development

Analysis of the use of Web 2.0 tools within the e-learning at the Zagreb School of Economics and Management

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Abstract

Zagreb School of Economics and Management (ZSEM) since it was found in 2002 is systematically using e-learning in education in the form of common Learning Management System (LMS) in all courses. Until today ZSEM has developed 150 e-learning courses and eleven standards for annual measurement of the quality of individual elements of developed e-learning course. Although the LMS enables different tools such as online discussions, quizzes, surveys, assignments etc., there is a possibility of using various multimedia content in order to improve quality of e-learning course and increase student activity within it. With development of Free Open Source Software (FOSS), there is an opportunity of using Web 2.0 tools in producing e-learning courses in order to improve teaching content and student migration from passive to active participant in e-learning.
In this paper, the authors will analyse the amount of using Web 2.0 tools in producing e-learning courses within the sample of courses at ZSEM. The authors will examine the expectations of teachers from using Web 2.0 tools within their courses and students expectations of using these tools in learning.

Keywords: *Web 2.0, e-learning, Learning Management System, Free Open Source Software, standards, quality*

1. Introduction

In distance education which is the basis of different learning form such as e-learning, web based learning, online learning and virtual learning, a need for providing interaction has always been an important issue [1].

Significance of interaction and using various tools has been underlined and very important for different interaction forms (student-teacher, student-student, student-content etc.). At Zagreb School of Economics and Management, e-learning has been for many years a part of the mission of the school and they are constantly working to improve the quality of the existing LMS and course content within it. Although all e-learning courses have been developed in accordance to 11 standards [2], there is a significant difference between the quality of individual courses. The difference can be seen in the amount of use of various tools within the LMS and some courses were ahead of others in the amount of activity on the Blackboard (Bb).

It is necessary to expand the scope of activities on tools that are not part of the Bb, but are available to all participants of e-learning courses. These tools are allowing greater student independence and autonomy, greater collaboration, and increased pedagogic efficiency.

Today's students are ready to participate. The members of the "Net" or "Millenial" Generation have been connected to the new technology throughout their development and they expect that teaching and learning will be more interactive, collaborative, and experiential, and that it will feature technological connectivity [3]. Various Open Source Software in recent years took the web very quickly. The name Web 2.0 has been referred to web-based technology, tools and services. [4].

Necessity of collaborative technology that leads the student toward achieving desired learning outcomes, requirement for flexible models that allow designers to begin at any given point in the process and purpose of technology using in the instructional design framework show that emerging technologies have an impact on new models of teaching and new ways of learning in distance education [1].

Web 2.0 gained popularity around 2004. The rapid evolution of Web 2.0 applications is offering new possibilities and perspectives in business, government, and especially in education. A number of higher education institutions have explored the educational use of Web 2.0 in Europe and in the USA and number of advantages or potentials have been highlighted. For example, it is suggested that Web 2.0 tools support constructivist approaches to learning and have great potential to socialise online learning to a greater extent than has previously been seen. The results of this research present four distinct categories of descriptions of Web 2.0 tools as conceptualized by the respondents. The conceptions were: communication tools, educational tools, professional tools and multi-purpose tools. The contextual focus was on presentation of lectures, personal assignments and group collaborations. The students highlighted Facebook, MySpace, Skype, Google Scholar, as the most commonly used Web 2.0 tools [5].

There is no doubt that Web 2.0 has changed and transformed access to information and communication. It provides user-created content platform applications, allowing users to contribute their knowledge in different formats like text, data, video and audio. The Web 2.0 applications hold profound potential in education because of their open nature, ease of use and support for effective collaboration and communication [6].

Today, many instructors are exploring the use of Web 2.0 tools in teaching and learning. Some instructors are critical of the use of technology in teaching content.
Although the e-learning have been present for many years at ZSEM, there is still space for improvement of teaching content at Bb. The main idea is to move away from the Bb and the tools integrated in LMS mentioned, and to explore what is offered outside the LMS in the form of Free Open Source Software. These software can improve the quality of the course content, increase the activity of students on the course and ultimately contribute to a better overall performance on the course. The goal of further research is to explore perceptions of the lecturers and students on the use of Web 2.0 tools in the process of teaching and learning and to explore the extent to which lecturers have implemented Web 2.0 tools in the course.

2. Research analysis and discussion

The aim of the research is to explore the use of Web 2.0 tools by lecturers at ZSEM and to explore their opinions about the benefits of using these tools to create course content. Besides the views of lecturers, the aim is also to explore the perception of the students about the usefulness of Web 2.0 tools in classroom. The research included 38 surveyed lecturers and 25 students. The data was collected in the survey, which included 16 different questions, opened and closed. If the question was closed the answer is offered in the form of Likert scale from 1 to 5, where a value of 1 indicates the lowest level of agreement with the question, and the 5 as the highest level. The survey was conducted using a Bb, e-learning system used at ZSEM. The structure of the respondents is quite heterogeneous because the respondents use internet technology in a different way.

The following hypotheses are highlighted:

1. Students find multimedia course content more important than lecturers.
2. Lecturers and students are not sure what the Web 2.0 tools are.
3. Lecturers are using Web 2.0 tools for private purpose more often than for professional purpose.
4. Students are using Web 2.0 tools for fulfilling the obligations of the course more often than lecturers for preparing the course content.

2.1. Testing the first hypothesis

To check the first hypothesis, the results of the surveyed lecturers and students are compared. The question was about the importance of multimedia course content in the eyes of the lecturers and also from student’s perspective.

Figure 1shows comparison of average grade of lecturer’s responses compared to student’s responses.

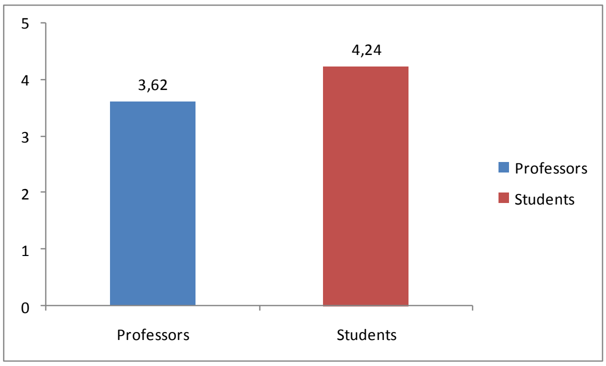

Figure 1. Comparison of average grade of lecturer’s responses compared to student’s responses

In Figure 1 it is obvious that students find multimedia course content more important that lecturers in preparing content. Average grade of student’s responses is 0,62 greater than grade of lecturer’s responses which is a significant difference in the perception of multimedia content between the two interest groups. To make this difference more emphasized, the lecturer was asked to answer in which amount the use of multimedia tools can influence on his course. At the same time the student was asked to answer in which amount the use of multimedia content can influence on his activity and success on the course. In Figure 2 it is obvious that students find that multimedia course content can influence on their activity and success on the course. At the same time lecturers don’t think that multimedia tools can have big influence on their course. The difference between these grades is 0,33.

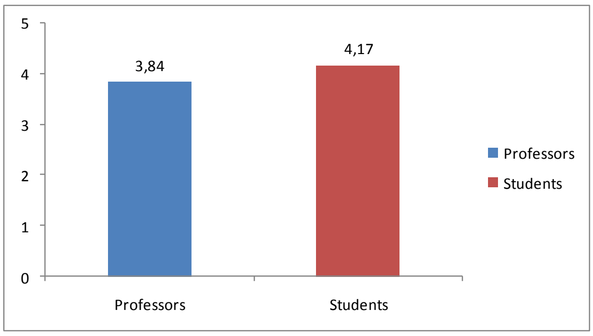

Figure 2. The difference in the average grade of students and lecturers on the impact of multimedia tools to the course

2.2. Testing the second hypothesis

To test the second hypothesis, it is important to ask questions that would check how sure lecturers and students are about real meaning of Web 2.0 tools. It is also important to check are they aware of using these tools daily.The assumption is that a large majority of them belong to the group of those who are not sure what the Web 2.0 tools are or even never heard of.

Figure 3 shows average lecturer's and student's grade of what they know about Web 2.0 tools and whether they have heard about them.

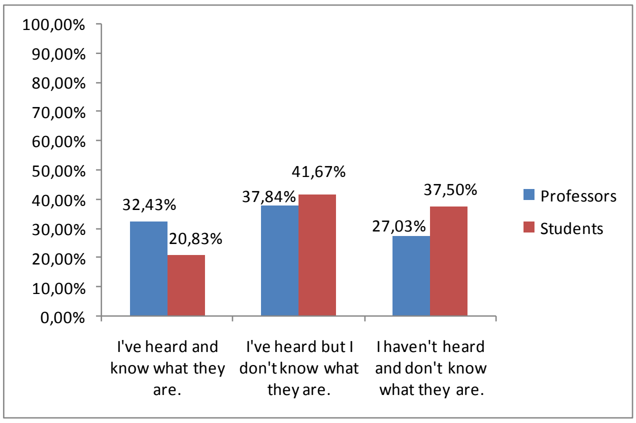

Figure 3. Average lecturer's and student's grade of what they know about Web 2.0 tools

From the Figure 3 it can be concluded that the majority of respondents are not sure what the Web 2.0 tools are and therefore are not aware of their use. Moreover, about 30% of students and the same lecturers, not even heard of Web 2.0 tools. The above graph also shows that 12% more lecturers than students have heard and know what the Web 2.0 tools are. It is an expected result since they have more experience working with internet technology in creation of course content.

2.3. Testing the third hypothesis

For testing the third hypothesis, it is necessary to examine lecturers in which amount they use Web 2.0 tools privately and in which amount for professional purpose. It is assumed that respondents use Web 2.0 tools for private purpose more often than or professional purpose. At Table 1 there is obvious difference in the percentage of private use of particular tools than in professional use.

Table 1. Average percentage of using specific Web 2.0 tools privately and within the course

Type of tool	Within the courses	Privately
YouTube	52,17%	58,33%
Facebook	13,04%	41,67%
Skype	17,39%	37,50%
GoogleDocs	13,04%	16,67%
Vimeo	4,35%	12,50%
I don't use	**39,13%**	**20,83%**

From Table 1 the difference in use of tools privately or professionally is evident. The biggest difference can be seen in the use of Facebook where only 13% of them use Facebook within the course they lecture. In private use 42% of them use Facebook. Moreover, the average percentage of using such tools privately is almost twice higher than grade of using these tools in professional purpose.

2.4. Testing the fourth hypothesis

To test the fourth hypothesis, in which it is assumed that students for specific purpose use Web 2.0 tools in larger amount than lecturers. The respondents have been asked are they using Web 2.0 tools in specific situations, for example communication, mind mapping, video, etc. In Figure 4, the distribution of average grades of student's and lecturer's responses is shown.

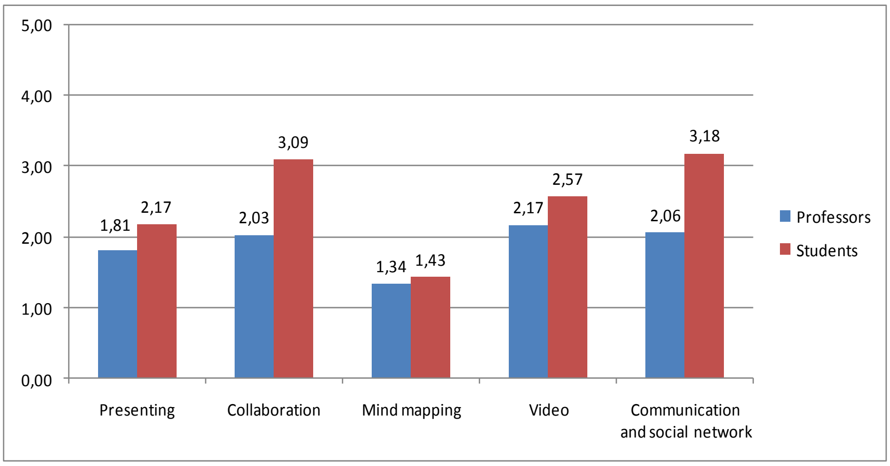

Figure 4. Distribution of average grades of student's and lecturer's responses of using Web 2.0 tools in specific situations

From the Figure 4 it is evident that students lead in all areas which means that students use Web 2.0 tools to fulfil the obligations of the course more than lecturers for creating the course content. The biggest difference can be seen in the area of communication and social network. The students use tools such as Skype, Facebook, Messenger or Twitter in big amount for fulfilling their obligations. This is the expected result since the students work together and communicate with each other using a variety of tools to address their obligations within the course. As for the results of the lecturers, it is evident that there is space for improvement and introducing Web 2.0 tools in tested areas.

3. Conclusion

It was shown that multimedia content is very important to students and also to lecturers in context of distance learning. The research revealed that student's experiences of Web 2.0 tools varied in the few different situations. Students use privately a big number of Web 2.0 tools, but also for fulfilling their obligations within course content.

As for the results of the lecturers, it is shown that lecturers don't use Web 2.0 tools in preparing course content so often or even at all. Some of them are not even sure what the Web 2.0 tools are. Lecturers use Web 2.0 tools in private purpose much more often than for professional purpose.

At ZSEM, the use of e-learning is a part of a mission and Bb has different tools integrated for course design. After this research it is obvious that there are opportunities for improvement in form of Web 2.0 tools. Students expect more interactive lectures so with these tools lecturers can implement dynamic into their courses.

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Sustainable m-Governance strategies for communities in tension: exploring the role of the grassroots champion

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Abstract

The purpose of this study is to establish a framework and reasonable benchmark standards for launching grassroots m-Governance interventions. The study will interrogate the strategies and specific technologies that have proven to yield good results; and the role of the grassroots champion is highlighted. The study furthermore seeks to uncover the preferences and/or indifferences of communities in tension to "development projects". It is understood that the notion of "community" refers to the "participant community" within the geo-social setting of the project. M-Governance typically involves the following considerations, namely - (1) transforming government services onto mobile platforms; (2) providing infrastructure and access via mobile technologies; (3) providing mobile applications for field workers to bring services to the community; and (4) providing flexible, smart and interactive informational and other services to the consumer. This study focuses almost exclusively on the latter. There is a huge body of knowledge extolling the merits of ICT4D, e-governance and m-Governance projects. This study will draw from this body of knowledge but focus particularly, but not exclusively, on the people aspects of these cases. This is an exploratory study with an emancipator agenda. Critical analysis is therefore central to the data analysis and information synthesis. Data collection on the state of the e-governance discipline will be conducted via literature study. Data collection on the role of the grassroots champion will draw from the experiences of the founder of the Reconstructed Living Laboratory (RLabs). This study seeks to establish a value and performance framework for unfunded or poorly funded grassroots m-Governance projects.

Keywords: *Community in Tension, grassroots champion, ICT4D, G-governance.*

1. Introduction

The deployment of m-Governance strategies for promoting the interests of communities in tension could be a very complex proposition. The requirement for launching even a basic service will necessitate infrastructure provision, government commitment, and community resourcing for participation. The sustainability of the venture will of course depend on the perceived value proposition of the intervention. Within a community in tension there are probably many competing interests for resources both at a community and government level.

This paper explores varies Information Communication Technology for Development (ICT4D) m-Governance projects highlighting particular factors contributing to its success at intervention. It also explodes the notion of community projects operating within a tension environment and the Founder of RLabs providing insights on how it's succeeded within the community of Athlone. ICT4D essentially means to draw from literature first [1] to enhance the outlook on the path forward oppose to self discovery of steps during an endeavour.

2. Background

The literature abounds with ICT4D, e-governance and m-Governance case studies which detail their intervention success factors. Many of the reported cases however relate to funded projects.

This study specifically explores the role of the “grassroots champion” operating within an unfunded or poorly funded context. It is proposed that the “grassroots champion” is central to the success of the project and (initially) takes on several roles in forging the viability and sustainability of the project. These roles might include that of project manager, community liaison, and software developer.

This study will focus on viability and sustainability considerations and delineates the various essential roles and milestones that are required for successful project delivery. An interesting aspect of the study is the introduction of the notion of “surrogate government or governance” involvement where intermediary functionality simulates government services through third party services within an information portal. The m-Governance engagement therefore runs parallel to the mainstream government service provision.

3. Purpose

The purpose of this study is to establish a framework and reasonable benchmark standards for launching grassroots m-Governance interventions. The study will interrogate the strategies and specific technologies that have proven to yield good results; and the role of the grassroots champion is highlighted. The study furthermore seeks to uncover the preferences and/or indifferences of communities in tension to “development projects”.

It is understood that the notion of “community” refers to the “participant community” within the geo-social setting of the project. M-Governance typically involves the following considerations, namely - (1) transforming government services onto mobile platforms; (2) providing infrastructure and access via mobile technologies; (3) providing mobile applications for field workers to bring services to the community; and (4) providing flexible, smart and interactive informational and other services to the consumer. This study focuses almost exclusively on the latter.

4. Literature Study

The literature below discusses the underpinnings themes within this paper.

4.1. m-Governance - The novelty of mobile governance

M-Governance describes the collaborations with stakeholders to guide decision making [2] and control by the utilization of the mobile infrastructure specifically mobile phones. M-Governance is undermined by inadequate understanding of the context environment, government agencies support and the adolescent stage of m-Governance strategies intervention as a whole.

The great importance of mobile governance strategies aims to improve on the existing e-governance strategies and - in addition, capitalize on a “mobile community” which is bound on using their mobile devices as their first and/or only choice. The mobile community is one of the biggest emerging markets. Sub-Saharan Africa Mobile Observatory [3] says South Africa in particular; in relation to other African countries, has showed a penetration level of 123% supporting over 50 million connections in 2012.

4.2. Community Informatics - in respect to “development projects”

According to Parker et al [4, 5] the term “development projects” simple put (typically) follows a top-down approach to address a particular problems within a community. Walton and Heeks [6] describe the underlying problem with embarking on top-down approach is the level of community participation in the initial stage. Community Informatics approach makes a clear distinction by understanding what the community interests are and what potential applications could be built to address those problems [5].

4.3. Communities in tension

Bridgetown is an area located in Athlone; Western Cape, South Africa. It is said to be a community in tension [7]. Parker et al [7] and describes a tensioned community as one that is in a state of "instability". Communities within these "tension"-areas; also know as Communities in Tension (CiT) describes a situation by highlighting four particular factors halts improving the state stability within the community. These four factors include economic development – income inequality. South Africa has the highest levels of social inequality [8] compared with other BRICS countries namely; Brazil, Russia, India, China. Furthermore more than half South Africa's population is living in severe poverty [9]. The third factor considers South Africa's educational importance. The fourth factor deals with the use of the technology and its effective use to address the above mentioned factors. A local champion or "grassroots champion" could be described as someone or a group of people or local organization that serves as a liaison best to represents a community's needs [5].

4.4. m-Governance projects success factors

Below describes certain cases where m-Governance was implemented with success. Each case highlights key factors deployed within a developing country with a key interest on milestones and context environment.

4.4.1. M-PESA - How Kenyans perpetuated mobile finance

A Kenyans pilot project turned commercial addresses the mobile consumer community with the ability to micro-finance. M-PESA is a "mobile tool" [10] which allows for mobile payments through the use of SMS technology on the mobile phone. Marvelled as a success; M-PESA , is an example of mobile technology intervention whereby user adoption grew so significantly it's regarded as world leaders in mobile money transfers [3] and most successful phone-based financial service [11]. Factors contributing to M-PESA adoption were the high cost of alternative e-payment facilities and lack of support from regular banks to reach people in rural areas contributed to the many users signing up [11]. Understanding the market provided a great opportunity and opportune business 'gap' to introduce to the public. If it wasn't without a partnership between Safaricom M-PESA won't have expanded at the rate they did [12].

4.4.2. Cape Gateway Development

The Cape Gateway Development (CGD) projects have been developing with intent to address e-government services to the Western Cape provincial government [13]. There is a hesitation on developing systems that might alienates potential uses [13] - implying mobile infrastructure. CGD has got the Western Cape government background for implementing e-government services, however mobile is a keen interest and is begging the questions on when it will be implemented in the CGD services.

5. Methodology

This study seeks to establish a value and performance framework for unfunded or poorly funded grassroots m-Governance projects.

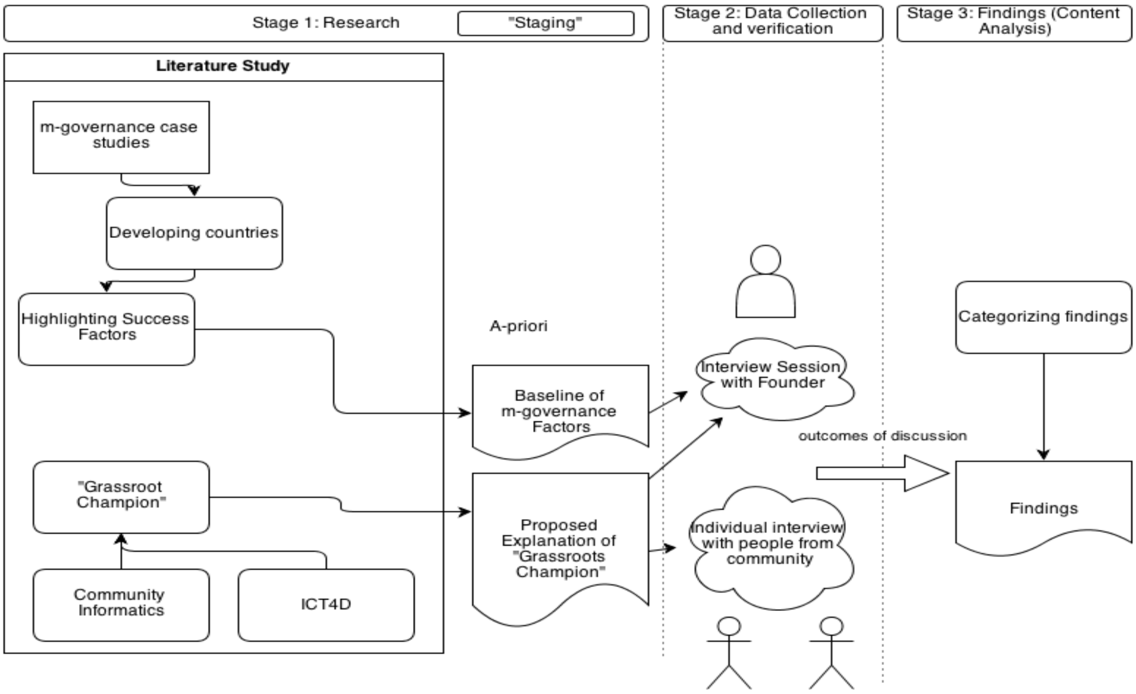

Figure 1. Methodology

The methodology established for this paper highlights three particular features; namely a literature study, Interviews sessions and the analysis of the findings.

5.1. "Stage 1" - Literature Study

Literature Study will provide understanding around m-Governance strategies short listing requirements and factors that contributed their success. The literature will serve as secondary data providing a basic understanding of how interventions were deployed and providing knowledge around terms such as "communities in tension" and "champion" would be explained. Five people that work at RLabs were interviewed. One interviewee was the Founder and the other interviewee holds leadership roles in RLabs.

5.2. "Stage 2" - Interviews

The literature will provide the background to the construction of questions to asked community members and the founder of RLabs. Interviews will be recorded so to draw further analysis afterwards. Interviews will be conducted in a semi-structured manner with predetermined question which would be constructed with help from the literature [14]. While open-ended interviewers provides plenty of understanding around someone's views and ideas, semi-structured interviews tries to stick within a "line of inquiry" keeping interviews more focused but less formal [14].

5.3. Interview Rationale

Interviews were further broken down into two sections whereby community members and the founder of RLabs were asked separate questions.
Community members were asked around following providing reference to community engagement;

- Establishing how people come across - or hear of, RLabs within the community.
- What their understanding were around the term "grassroots champion" / or whether they heard about it before.

The founder of RLabs was asked specific questions that related to how RLabs was formed and sustained within a community setting;

- Exposing the steps the organization has taken with respect to role players and strategic partnerships.

- Their use of technology and applying it in the community to alleviate social inequalities.
- How to address sustainability being an NGO in a tensioned environment.

"Stage 3" - Analysis
The findings will provide a richer understanding of context. Findings will be categorized and key topics will be highlighted and discussed.

6. Results

The results were categorized and grouped according to the above mentioned themes.

6.1. Grassroots Champion

The terms "Grassroots champion" were described as meaning the following;

1. The expression "down to earth" and "leads by example" as among the expressions best describes an approachable character(s) that is a leader within a community.
2. A community member said "...he [Marlon Parker] has this thing that he doesn't say no" and a grassroots champion does not see problems but "an opportunity to do something". 'Something' implying to proceed in a manner that potentially alleviates community problems.
3. "Relatability" among community members; "how he [Marlon Parker] made things happen for himself" provided the understanding that the founder's story help inspire other community members. This statement helped provide understanding that the founder's story induced in this particular community member a self reflexive process of their own circumstance within environment.
4. Champion Sustainability; the founder described a grassroots champion as being someone that would drive a community initiative within the context of that community. It was important to note that community members often made a note of a grassroots champion not necessarily someone with educational background but is someone that is willing to empower the next person to learn new skills – "creating a culture learning" one community member mentions.

6.2. Governmental services

Community members highlighted potential mobile governmental services which they see potential on using. These services included;

Table 1. Potential m-services

Potential m-Service	**Details**
Housing Projects	• Providing access to information. • Housing applications. • Transparency; communication between applicants to eventual home owner. • Information should be localised.
Newsletters	• Local news provided to members via their mobile phone. • Information should be localised.
Children Safety	• Social workers to check up on children's school attendance. • Providing access to parents on the whereabouts of their children.
Refusal Removal	• A community member shares that dirt bins has a street value of R350. A system that displays arrival times of refusal trucks to avoid bins been put out too early and potentially stolen.

6.3. Technological

The founder mentions that without the use of technology RLabs wouldn't have existed. "Technology was an enabler" and a "catalyst to change" in contrast to "being consumers" of technology the founder adds. A community member suggests building a Mxit application. "Mxit is simply an application that you open on your phone, and you log in and begin chatting" [15] additionally it's a platform which allows information provision portals to be used within Mxit. Another member from the community points out that libraries and community centres are still the first place to find information and proposed build a physical device with buttons that plays audio clips about a particular information that government and local municipality provides i.e. police, ambulance and hospital information. The point eventually come out that many people do not have smart phones and "…we are talking about not just about youth, you know…youth access things differently but we talking about the older group" community member adds.

7. Discussion

Below are discussions that arose from the interview sessions.

7.1. The misguided approach

It this case, a formulation of a m-Governance strategy if it were to be created within South Africa using a "generic" [5] ICT4D approach, community interests would be researched often using indirect [16] channels. The approach taken by RLabs was no more an approach but an approach which emerged from the community. Referred to as a "community driven approach" [4] whereby its initiation and sustainability was broad on by asking the community what interested them and address concerns which in this case helped create; a technological intervention, a system that tries and alleviate the Drug Abuse within the community.

The underlying difference is when this initiative started there was no project and no approach to begin with. Community Informatics philosophy's however was fulfilled more so than an ICT4D agenda was - which were instructed on bridging the 'digital gap'. Gurstein [5] supplies his perspective on technology contributing to innovation; within a community, should be brought on by community members and not be implemented (forcefully) in a community as a solution.

7.2. Strategic partners for sustainability

Not a new notion but context will differ. The purpose of this study were to understanding the importance of understanding why RLabs stood out as a NGO operating within an environment whereby its community were said to be operating with instabilities [7]. RLabs like M-PESA spent time establishing a presence before proceeding to the next stage of its development. M-PESA acquired strategic alliances with regular banks as well as Safaricom. RLabs sought appropriate partners to address community concerns and formed from an established presence within the community. When it came to the notion of sustainability there were three aspects that stood out;

1. *Strategy partners to solve particular community problems*. The founder shares key roles players such as Impact Direct, Finnish Foreign Minister, Cape Peninsula University of Technology (CPUT). All partners however brought a level of expertise around understanding environment.
2. *Offering entrepreneurial courses with co-ownership;* RLabs will invest in potential business ideas that would emerge from the community and when that business becomes successful a portion is given back into RLabs.
3. *Social franchise*; Franchising propagates the social model which RLabs had engineered to other developing countries. Sustainability here is not so much funding - provided there are partners willing to provide support, but to establish a brand awareness of social impact and community interest in other parts of the world.

8. Conclusion

There is currently no m-Governance strategy for communities in tension. Research provides the ideal conduit for accessing information on the research environment; however it merely takes a few minutes with community members to understand what appropriate services would be feasible and important to address. Sustaining a community's interests with the use of technology - not exclusively mobile infrastructure, and not exclusive one partner, is important to establish with regards to approaches to implementing future m-Governance strategies.

There was a strong emphasis that a grassroots champion is someone who exists and lives in a community and is willing to give back to the community the skills they learnt. Community members provided incited with regards to accessing information which did not always include mobile devices. Transparency is still a factors as well as localising content to suit appropriateness of content is mentioned in literature and its evidence that the findings bears such aspects of uncovering what communities needs from government.

It was the researcher's a priori perspective that a Government to Citizen (G2C) approach should've been understood to be the most appropriate method of a system following a top-down understanding serving to implement particular governmental service via mobile. It's now the researcher's perspective that an intervention at grassroots level should be implemented with a bottom-up approach perspective looking towards a Citizen to Government (C2G) system whereby new services should be broad on by a community and communicated to local government.

8.1. What's next?

This paper is by no means the end but merely an attempt to uncover the understanding of the Athlone, Cape Town area. The findings will be expanded on in the future furthermore time restrictions on the analysis of primary data have shortened the discussion. The researcher is currently working on a C2G application; called miGOx, which provides users on the Mxit platform the opportunity to comment around several governmental services in the form of closed-ended questions providing incite on mobile community.

9. Acknowledges

A special thanks to the community members that agree upon to being interviewed. A special thank you to the founder of RLabs; Marlon Parker, for opportunity to be interviewed and providing space to conduct the interviews in.

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Presenter: The paper is presented by Kurt Appolis

Efficacy of FOSS Deployment

Learning embedded programming using the Arduino microcontroller for aquaculture environmental monitoring

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Abstract

Using the Arduino platform in teaching programming skills is intuitive for learners. This paper presents the design and implementation of the measurement and control of environmental conditions for aquaculture using Arduino microcontroller platform. Aquatic animals suffer from the presence of dissolved ammonia in the water. To prevent the substance causing mortality in fish a means of programming a microcontroller algorithm associated with appropriate sensors to monitor the environment is implemented. Issues of process monitoring have become highly significant in engineering practice (design and manufacture), it is also important for society in pursuit of the sustainable development. The monitored data is: the water temperature; the pH level in the water; and the ammonia level. The use of colours (green, yellow, red) through light emitting diodes (LED) and a buzzer as system indicators is useful. The system implemented for monitoring of the environmental conditions requires that the Arduino would light the green LED for the condition where the water is at right temperature for the fish; the yellow LED when the temperature could present a possible problem; the red means critical temperature is reached. This condition activates the global system for mobile (GSM) device and the buzzer. Furthermore the data monitored is displayed on a computer as well as their graphs in the real time operation via the processing software. A laboratory scale system was successfully implemented and the addition of electronic monitoring complemented the visual monitoring of the operator.

Keywords: *Analog computers, Data visualization, Temperature measurement*.

1. Introduction

The concentration of the un-ionized ammonia is toxic to aquatic life due to multiple reasons such as a decay of uneaten food, organic matter; a starved fish will cause some ammonia etc. [1]- [2]. The water temperature and its pH are contributing factors to ammonia concentration. It is imperative to monitor water temperature and the pH in order to determine the threshold value of ammonia. By using the Arduino platform to construct the monitoring system it has the advantages of allowing a custom designed solution and also allows the system to be easily portable [3]- [4]. A continuous measurement of the environment will allow the best treatment of aquatic life and also to intervene timeously when detecting dangerous levels of ammonia. The purpose of this study was to improve the life expectancy of fish by means of monitoring the water temperature, the water pH level and dissolved ammonia then subsequently to send alarms to an operator when hazardous conditions arise in the aquaculture environment [5].

1.1 Monitoring system design

The algorithm developed in the programming of the microcontroller is complemented by the addition of sensors (pH electrode associated with pH controller Micro px1 and the LM35 temperature) and indicators such as LEDs, GSM commander, buzzer and a PC display. Figure 1 portrays the system design and consists of the following outline:

1. The reading of the data from the sensors in voltage.
2. Converting voltages from different sensors to a real value.
3. The microcontroller will make available data in serial communication.

4. Processing software would grab the data form serial communication and display it on computer screen.
5. The Processing software would graph the data on PC screen.
6. The Arduino will manage the preset condition of the alarm system and send SMS.

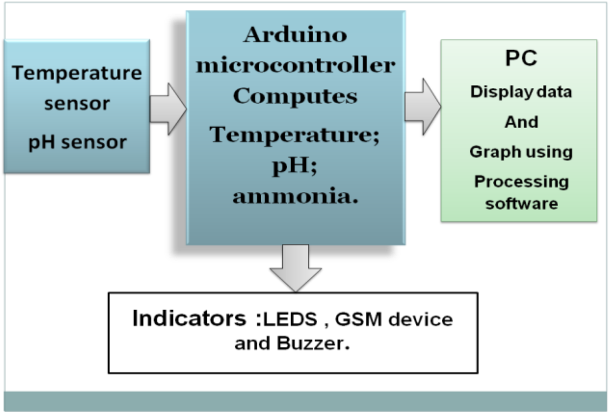

Figure 1: Block diagram of the system

1.2 System operation

The system is designed to monitor several elements in the water environment via a data acquisition system. The values measured are: water temperature; pH level and the un-ionized NH_3. These values are displayed numerically and in graphic format on the computer (see for example Figure 2). The two sensors that were measuring the pH level and the temperature were both connected to the Arduino board. The Arduino read from the two sensors through its analogue pins and computed the water temperature, pH level and the un-ionized NH_3 ammonia. The data is displayed on the computer screen via processing software program, so that the user could visualize it in real time at which the data is being taken (see for example Figure 3). The Arduino board was supplied with three LEDs (green, yellow and red), buzzer and GSM device so that a user could be alerted for intervening in the site according to the following actions:

1. The green LED is permanently ON and the rest of the LEDs are OFF, which means the water temperature is in a range of 12 to 22°C [6]. This implies the environment is stable and safe for the fish regarding the temperature.

2. As soon as the yellow LED turns ON, the rest LEDs are OFF. This is a warning zone ranging from 23 to 25°C [6]. This also gives a time to the user to regulate the environment before the worse situation.

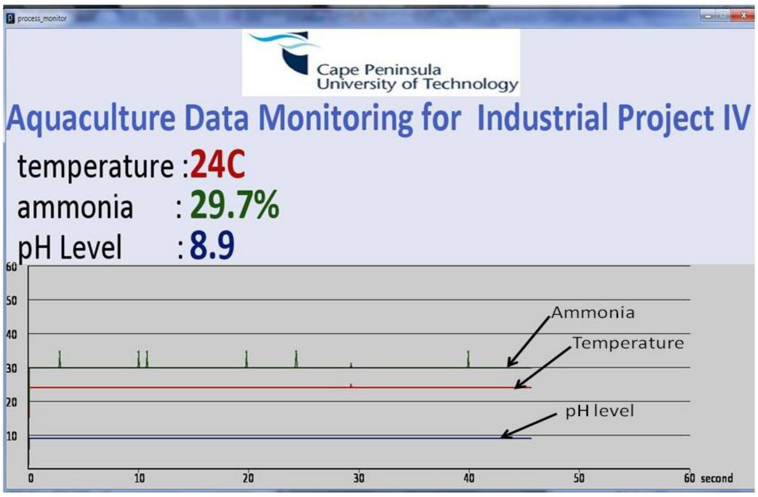

Figure 2: Display of the data monitored

3. Finally, the worst case scenario is where temperature ranges from 26 to 36°C, which is a critical temperature condition for the fish [7]. The red LED turns ON and others LEDs are OFF. In addition the Arduino would activate the additional device (GSM Commander) to send an SMS directed to the operator for the urgency and the alarm will sound until the situation returns to normal environment temperature ranging from 12 to 22°C.

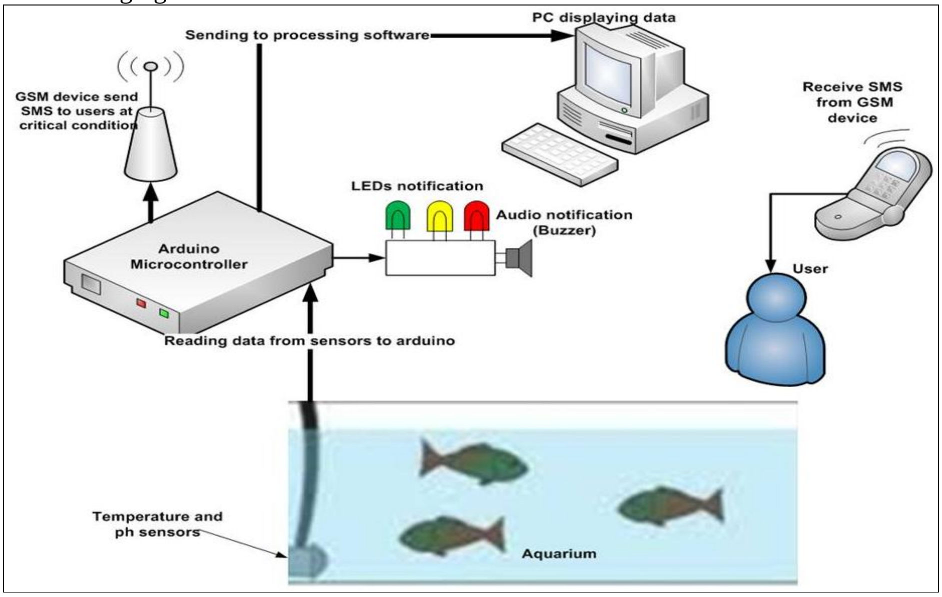

Figure 3: System operation

2. MATERIALS AND METHODS

2.1 The pH data measurement

To obtain the pH value in the monitoring process, the pH sensor and the pH controller model Micro-PX1 have been used as a transducer to get the data. However, the output current of the transducer varies from 4-20mA depending on the pH. By correspondence 4mA was referring to 0 and 20mA was referring to 14 in pH scale. The microcontroller used has a built-in analogue voltage reading. To convert the output current to voltage, a shunt resistor has been used the resistance was connected between the ground and one of the analogue inputs of the microcontroller for a reading purpose. The input of the Arduino would read analogue from 0 to 5 volts. Hence, the shunt resistance must have a suitable value so that the maximum current voltage output of 20mA should be converted to 5 volts at the analogue input of the Arduino. The shunt resistance value was calculated based on the formula of the voltage current relation to the resistance voltage = current × resistance.

$$\text{Thus } resistance = \frac{voltage}{current} = \frac{5\,volt}{20mA} = 250\Omega \qquad (1)$$

The pH was measured on a scale of 0 to 14 which corresponds to a 0 to 5 volts scale. This implied that the pH could be represented as a straight line, which could be determined by its gradient (see figure 4). In order to derive the equation that would determine the real value of the pH, since the sensor produced a voltage value; the pH sensor probe was immerged into a 20ml container of pH buffer solution 4.01. The multimeter was calibrated to 20mA and was connected in series with the pH device. The value read on the multimeter was 2.0059 volts, by repeating the same process with a pH buffer solution 10, the reading on the multimeter was 3.081 volts. From the values acquire by the multimeter, the straight line equation derived was as follow:

$$\text{pH} = 2.78 \times analogue_{voltage} - 1.56 \qquad (2)$$

For testing the pH probe was immersed in 20ml of tape water of pH buffer solution 10 and 4.01 for 5 hours each.

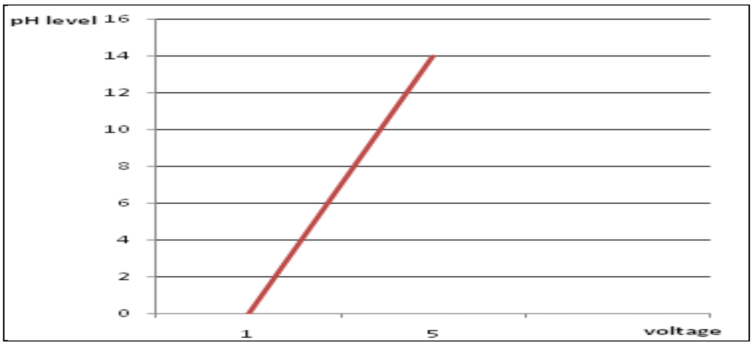

Figure 4: pH level vs. 5 volt analogue input.

2.2 Temperature measurement

The LM35 is an accurate temperature sensor which was used. The mechanical characteristics are consisted of 3 pins. The first pin was connected to a constant voltage of 5 volts from Arduino. The second pin was an analogue output that was connected to the one of analogue input of the Arduino board and the last pin was grounded. The actual output reading from the sensor was in voltage, not in degree Celsius. So, the voltage obtained was converted into degree Celsius to get the real temperature value. The reference voltage of the sensor was set to 5V with a resolution of 1/1024 from the Arduino board .To obtain the temperature value, the analogue voltage reader was used in the algorithm utilising the equation below:

$$temp = \frac{5.0 \times analogue_{voltage} \times 100}{1024} \qquad (3)$$

The temperature sensor was subjected to a reading test with the microcontroller. For the experiment, the following apparatus were used; a stove and a thermometer. The stove was set to a sequence of predetermined set point values of 25°C, 30°C, and 35°C for 5 hours for each individual set point value. The thermometer and the Arduino connected to LM35 sensor were taking the measurement, the purpose of alerting the normal and the critical temperature, the LED, the GSM device and the buzzer were connected to the microcontroller.

2.3 Ammonia measurement

As mentioned above, the determination of the ammonia depends on the relationship between the data captured previously (i.e. temperature and the pH level). This meant that the two first data were crucial in the finding of the ammonia in the tank. The ammonia measured was simply a mathematical application of equation that was in relation with temperature and ph level. The Arduino computed the ammonia using the temperature and ph values. The equilibrium equation relative to the concentrations of NH_4^+ and NH_3 according to the pH [8] is the following:

$$Ka = \frac{[H_3][H^+]}{H_4}$$

The concentration depending on the temperature is $pKa = \frac{0.9101+2729.92}{273.2+T}$ (4)

The un-ionised ammonia using the pH and temperature solution will be calculated [9]

$$\text{Unionised } NH_3\ (\%) = \frac{100}{1+10^{(10.06-pH-0.327T)}} \qquad (5)$$

2.4 Displaying measured data

Additional software named Processing had been introduced to interact with Arduino on serial communication in the process of visualizing the operation of data captured in real time and also by plotting the graph of data captured with the Arduino [10]- [11]. To display the data on the PC screen via processing software, the first step was to import Arduino library into processing. Then the next step was to fetch the bunch of data from the serial buffer in string; and separate each data (i.e. temperature and pH) then the temperature was converted into integer number and the pH into floating point number see the (figure 5 & 6). To graph the data in the real time operation, multiple methods were used. The suitable one was, after getting the data that was measured from the Arduino and put them into serial communication buffer the following would be:

- The processing software was taking the data from the serial buffer and then put them into an array. The aim of using array is to store each data captured in specific memory so that it may be easy to use the previous values and the actual data captured. Those values represented the y axis of the graph and x axis is represented the time increment of one millisecond.
- So to plot the graph it was necessary to define two points, the first points were the previous values of the temperature, ammonia and pH versus the value x-1 and the second points were the actual values of the temperature, ammonia and the pH versus the value of x. Each iterate of the loop in the software occurred at 1 millisecond, for the previous and the actual data to plot.
- The necessity to change the scale was better for the purpose of observing the plot in a bigger scale. The actual obtained value has been multiplied by a coefficient of 2.5 (see figure 3).
-

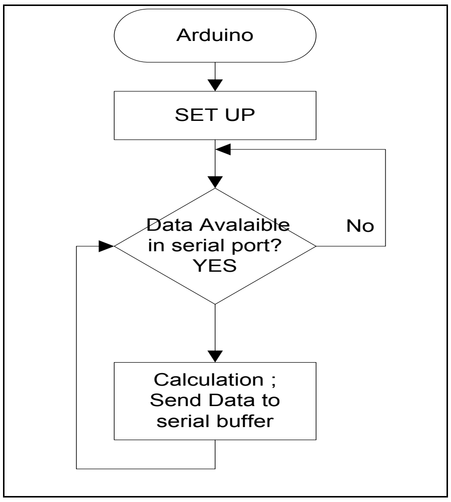

Figure 5: Arduino flowchart

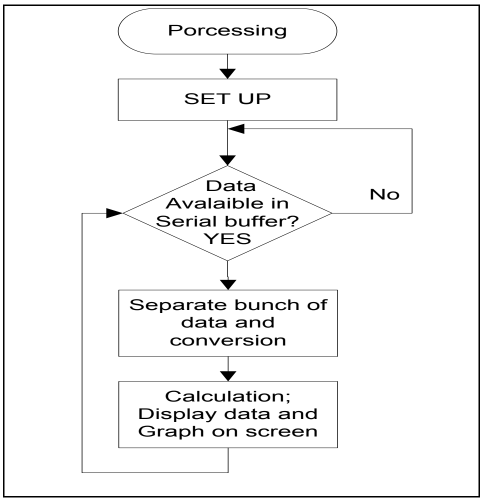

Figure 6**:** Processing flowchart

3. RESULTS

After heating the room with three different set values of temperature: 20°C, 25°C and 35°C. The results were displayed using the microcontroller via processing and thermometer as seen in table 1. At 20°C the green LED was ON as soon as the temperature reached 20°C the yellow LED was ON and the green switched LED OFF. Finally, at 25°C the red LED was ON and other LEDs were OFF, therefore, an SMS was sent from the GSM mode and the buzzer was activated.
As shown the table 2, as soon as the probe was immersed in pH solution 10 the processing software gradually displayed the value of the pH and stayed at 10. When the probe was plunged into 4.01, the software showed the decrement of the pH value to 4.01 (see in figure 3 below). Any other changes in either pH level or temperature will change the value of ammonia and base on the mathematical equation (2).

Table 1: Temperature test measurements

Heat set	thermometer	microcontroller
20°C	20°C	20°C
25°C	25°C	25°C
35°C	35°C	35°C

Table 2: pH test measurement

pH buffer	microcontroller
10	10
4.01	4.01

4. DISCUSSION

4.1 The temperature monitoring was accurate when one compared to the results obtained with the thermometer see table 1. The monitoring system has a fast reading to any fluctuation of the temperature in the environment.

4.2 The table 2 presented the results from the pH measurement by the microcontroller compared to the buffer solutions. It has been noticed that the measurements were accurate. Furthermore, when the system was submitted to a brutal fluctuation of the pH in order to see how fast the system could detect the change in pH level. The figure 8 showed the decrement and increment of the pH level according to the time. Therefore, time took to read a change from pH 5 to pH 7 was 26 seconds and from pH 7 to pH 4 was 30 seconds.

4.3 Referring to formula (5), the results of ammonia obtained by the microcontroller conformed to the calculated values. In addition, the ammonia was more influenced by the variation of the pH more than the temperature. For a very small deviation of the pH, the value of ammonia augment or reduce significantly see figure 9 below.

4.4 When taking the reading with only one sensor the value obtained from the reading was accurate but as soon as another analogue reading was added, the measurement was distorted. The problem was that the Atmega microcontroller on the Arduino has only a single ADC which acted like a multiplexer for all the other the analogue pins. When using the analogRead() function, the multiplexer connects the pin you are reading to the ADC. This concept works pretty well for low impedance voltage sources. It takes time for a high impedance sensor like temperature sensor to change the voltage at the ADC after this switch of pins [12].

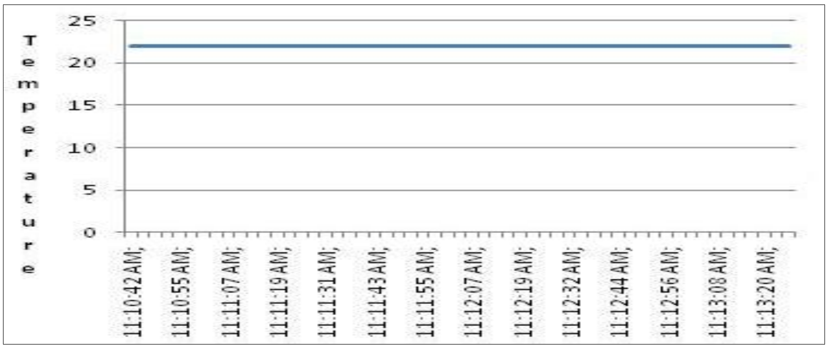

Figure 7: The water temperature

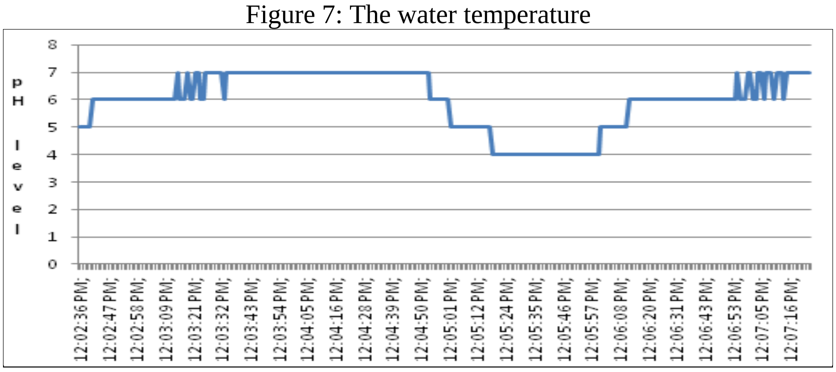

Figure 8: pH sensor response

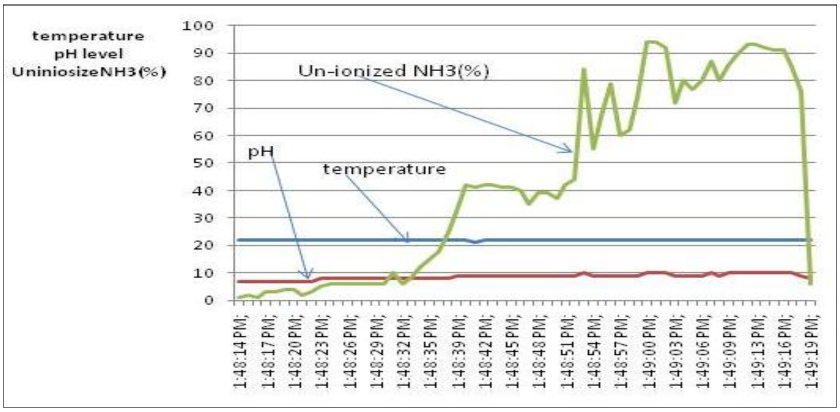

Figure 9 Ammonia, temperature and pH monitoring

6. Conclusion

The data monitoring system allows users to check different aquaculture parameters and take action when it is necessary. Hence, the system designed covers the aspect of the security of aquaculture environment in terms of monitoring the toxicity of the ammonia. The design is based on hardware and software implementation. The Arduino microcontroller platform is the main tool of design and implementation of the data monitoring system. It is a useful contribution that addresses issues of design and implementation in testing and process monitoring of engineering systems aimed at environmental sustainability. Through integrating various electronic monitoring segments for digitisation of results, analysis and reporting the implemented solution helps to improve the system effectiveness.

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Presenter: This paper is presented by Aminou Moussavou Anges Akim

Design of Low Voltage DC Microgrid System for Rural Electrification in South Africa

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Abstract

This paper entails the design of a low voltage DC microgrid system for rural electrification in South Africa as an educational tool for students interested in full DC systems for rural areas. Solar energy is freely available, environmental friendly and it is considered as a promising power generating source due to its availability and topological advantages for local power generation. Off-grid solar systems are perceived to be a viable means of power delivery to households in rural outlying areas in South Africa as solar panels can be used almost anywhere in the country. The design presented in this paper is based on the power demand estimation, photovoltaic panel and battery sizing, and wire selection for the distribution system.

Keywords: *Battery storage, DC loads, Photovoltaic.*

1. Introduction

Our electric power system was designed to move central station alternating current (AC) power, via high-voltage transmission lines and lower voltage distribution lines, to households and businesses that used the power in incandescent light, AC motors, and other AC equipment. Today's consumer equipment requires conversion of AC power into direct current (DC) for use, and that conversion typically uses inefficient rectifiers.

Increases in global energy costs, coupled with the warming of the earth's atmosphere due to greenhouse gas, are energizing a worldwide call for clean and efficient energy sources and architectures. On the other hand, globally over 1.3 billion people are without access to electricity [1]. Most of them live in rural and remote areas of developing countries, with a more dispersed population density; many of whom are either or below the poverty line. South Africa, for its part, has 12.3 million people without access to electricity [2]. Meanwhile, there is an outburst of interest in the use of renewable energy source to reduce greenhouse gas emissions. Renewable energy generation typically produces DC power, making it a viable distributed source for the low voltage DC microgrid system which is viewed as the best solution of power delivery to households in outlying areas where the utility grid is out of reach.

This project entails the design of a stand-alone low voltage DC microgrid system to power a fully DC single house in outlying areas. When considering the electrification of rural areas it is important to design systems that are reliable and require little maintenance as in these areas frequent repairs and replacements might not be easy. Efficient and low power consumption DC home appliances that meet the basic needs of a simple house are considered first for power demand estimation and from that a simplified solar system which consists of PV panel, MPPT charge controller, battery and wires, is designed as a low voltage DC microgrid system to supply sufficiently the energy demand.

Much research has been carried out into many aspects of rural electrification. One of the main aspects for the slow pace of rural electrification is simply the enormous cost associated with extending electricity grids to rural areas or establishing isolated mini power systems for rural communities [3]. South Africa is a large country and has many rural areas. There is always no grid connection to outlying rural areas and many of these rural areas remain without access to electricity. Grid extension projects are time intensive and require large capital investment. Long distance needed to be covered by the grid to reach these outlying areas make it too expensive to be feasible. Moreover, as the areas are sparsely separated and have a low power demand, the expense of extending the grid may not be worth the benefit that it would bring.

Electrification of these areas requires new and cheaper technologies. It is more viable to directly use the power generated by a distributed renewable energy source nearby. This eliminates the enormous cost associated with extending electricity grids and as well as losses due to DC-AC conversions, to the transmission lines, and to AC-DC conversions inside appliances. Moreover, 12V (or 24V) DC appliances are relatively inexpensive compared to AC appliances as they don't require buck converters to step down the 230V AC to 12V (24V) DC required by the appliances.

2. System Design

Hybrid Renewable Energy Systems have been accepted as possible means of electrifying rural outlying areas where it is too expensive to extend the grid to supply them. As stipulated in the introduction, the system is intended to power households and it must be cost effective; therefore, only solar energy system is retained. Figure 1 shows the overview of the low voltage DC microgrid system.

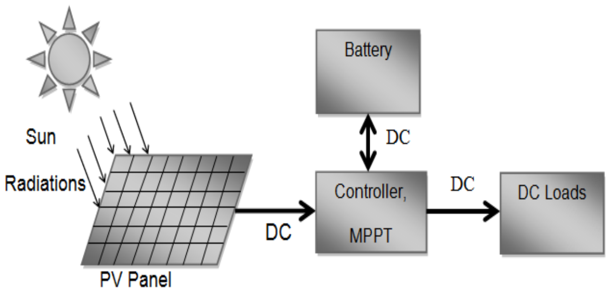

Figure 1. DC microgrid system. [4]

2.1. Loads selection and energy demand estimation

The 12V DC loads in the Table 1 below have been selected:

Table 1. DC loads and power demand. [5]-[9].

No	Appliances	Power
1	Phocos LED lamps	2×9W
2	Phocos TFT-LCD TV	5W
3	Engel Fridge SB47F	30W
4	Sangean Portable radio	6W
5	RoadPro Portable Fan	6W

From Table 1, daily energy demand can be estimated. Table 2 shows daily energy consumption.
Table 2

Table 2. Energy consumption estimation

No	Appliances	Energy estimation
1	Phocos LED lamps	18W×7h
2	Phocos TFT-LCD TV	5W×12h
3	Engel Fridge SB47F	30W×18h
4	Sangean Portable radio	6W×4h
5	RoadPro Portable Fan	6W×7h

The energy consumption estimated in Table 2 above gives a total daily average of 792Wh for a summer day.

2.2. Photovoltaic generator

A photovoltaic (PV) generator is the whole assembly of solar cells, connections, protective parts, supports etc. [10]. A photovoltaic (PV) generator converts sunlight energy into electricity. The energy produced by solar system is reliant on climatic conditions.
A photovoltaic system is comprised of cells at a basic element level. These cells can be connected together in series to form modules (or Panels). Figure 2 shows a moderate model of a PV cell used in this paper.

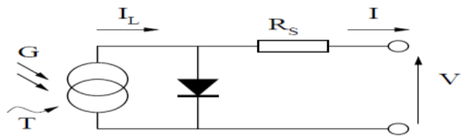

Figure 2. Circuit diagram of the PV model [11]

This model consists of a current source (I_L), a diode (D), and a series resistance (R_s). The net current of the cell is the difference of the photocurrent, $I_{L,}$ and the normal diode current $I_{o;}$ the model included temperature dependence of photocurrent I_L and the saturation current of the diode I_o. The equations which describe the I-V characteristics of the cell are [10]:

$$I = I_L - I_o[e^{q(\frac{V+I.R_s}{nkT})} - 1] \quad (1)$$

$$I_{L(T)} = I_{sc(T1)} + K_o(T - T_1) \quad (2)$$

$$I_{L(T_1)} = (\frac{G}{G_{(nom)}})I_{sc(T_1)} \quad (3)$$

$$I_{o(T1)} = \frac{I_{sc(T1)}}{(e^{\frac{qV_{oc(T_1)}}{nkT_1}} - 1)} \quad (4)$$

$$I_{o(T)} = I_{o(T1)}.(\frac{T}{T_1})^{\frac{3}{n}}.e^{\frac{-qV_{g(T1)}}{nk(\frac{1}{T}-\frac{1}{T_1})}} \quad (5)$$

$$R_s = -\frac{dV}{dI_{V_{oc}}} - \frac{1}{X_v} \quad (6)$$

$$X_v = I_{o(T1)}.\frac{q}{nkT_1}e^{\frac{qV_{oc(T1)}}{nkT_1}} \quad (7)$$

Where:
I_L is the photo generated current (A);
I is the net cell current (A);
I_o is the reverse saturation current of diode (A);
q is the electron charge (1.602×10^{-19}C);
V is the cell output voltage (V);
Rs is the resistance inside the cell (Ω);
n is the diode ideality factor (takes value between 1 and 2);
k is the Boltzmann's constant (1.381×10^{-23}J/K);

T is the cell temperature in Kelvin (K);
T_1 is the cell temperature at the Standard Test Condition (STC), given as 25^oC or 298K;
$I_{sc(T1)}$ is the short circuit current (A) at T_1;
K_o is the temperature coefficient of I_{sc} (%/^oC);
G is the irradiance (W/m^2);
$G_{(nom)}$ is the normalized value of irradiance at STC ($1000W/m^2$);
$V_{oc(T1)}$ is the open circuit voltage of the cell at T_1 (V);

The MATLAB script used to compute the equation (1) of the I-V characteristics is the Model of Photovoltaic Module in MATLAB by Francisco [10]. A typical I-V characteristic of the solar panel is shown in Figure 3. And the P-V characteristics of the solar panel at two different atmospheric conditions are shown in Figure 4.

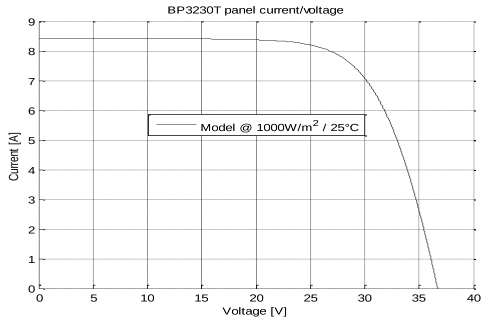

Figure 3. I-V characteristic of the solar panel.

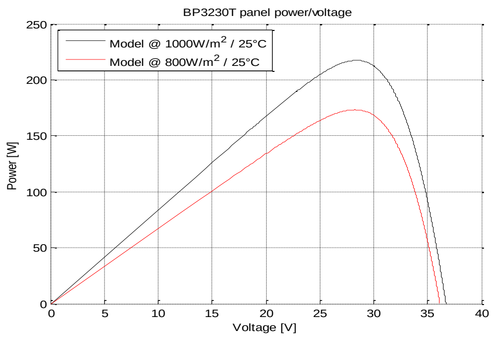

Figure 4. P-V characteristics of the solar panel

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Koutroulis [12] presents the following methods of calculating the power of the PV panels at the specified temperature and the irradiance:

$$P_{mp} = N_s.N_p.V_{oci}.I_{sci}.FF \tag{8}$$

$$I_{sci} = [I_{sc} + K_o(T_c - T_1)]\frac{G}{G_{(nom)}} \tag{9}$$

$$V_{oci} = V_{oc1} - K_v.T \tag{10}$$

$$T_c = T + \frac{NCOT - 20}{800}.G \tag{11}$$

Where:
N_s is the number of series PV panels;

Np is the number of parallel PV panels;
V_{oci} is the open circuit voltage at the specified temperature and irradiance;
I_{sci} is the short circuit current at the specified temperature and irradiance;
FF is the fill factor of the panel;
I_{sc} is the short circuit current at STC;
K_o is the temperature coefficient for short circuit current;
T_c is the calculated temperature;
T_1 is the STC temperature at 25°C;
G is the irradiance;
G_{nom} is the irradiance at STC given as 1000W/m^2;
K_v is the temperature coefficient for open circuit voltage;
T is the PV operating temperature;
NCOT is the Nominal Cell Operating Temperature.

The peak power for PV sizing is calculated as:

$$P_p = \frac{E_d}{\eta_T . peaksunhours} \tag{12}$$

With:

$$\eta_T = \eta_1 . \eta_2 . \eta_3 \tag{13}$$

Where:
E_d is the daily energy demand;
η_T is the product of component efficiencies;
η_1 is the wiring efficiency (typically 90%);
η_2 is the charge controller efficiency (90%);
η_3 is the battery efficiency (typically 90%).

In the power versus voltage curve of a PV panel there exists a single maxima of power (peak power corresponding to a particular voltage and current). The efficiency of the solar PV panel is low about 13%. Since the panel efficiency is low it is desirable to operate the panel at the maximum power point so that the maximum power can be delivered to the load under varying temperature and irradiation conditions. This maximized power helps to improve the use of the solar PV panel. A maximum power point tracker (MPPT) extracts maximum power from the PV panel and transfers that power to the load.

The controller is sized either with equation (14) or equation (15).

$$I = I_{sc} . F_{safe} \tag{14}$$

$$I = \frac{C_n}{t} \tag{15}$$

Where:
I_{sc} is the PV short-circuit current;
F_{safe} is a safety factor;
C_n is the rated capacity of the battery;
t is the minimum amount of hours of operation.

2.3. Battery storage

Because of the intermittent solar irradiation characteristics, which highly influence the resulting energy production, the major aspects in the design of the PV systems are the reliable power supply of the consumer under varying atmospheric conditions. Therefore, a means of energy storage must be

implemented in the design of a stand-alone solar system, and will be used to power the loads during night hours and cloudy days.
Cell batteries are currently the most used form of energy storage in the solar system. Lead acid batteries are the one considered in this paper as they are the cheapest and most popular.

When sizing a battery, two major parameters must be taken into consideration, the State of Charge (SOC) and the Depth of Discharge (DOD) of the battery. The battery, with total nominal capacity C_n (Ah), is permitted to discharge up to a limit defined by the maximum permissible depth of discharge DOD (%), which is specified when designing the system. Koutroulis [12] calculates the capacity of the battery at a point in time, t, as follows:

$$C_{(t)} = C_{(t-1)} + \eta_B \left(\frac{P_{B(t)}}{V_{BUS}}\right)\Delta t \tag{16}$$

Where $C_{(t)}$, $C_{(t-1)}$ is the available battery capacity (Ah) at hour t and t-1, respectively, η_B=80% is the battery round-trip efficiency during charging and η_B=100% during discharging, V_{BUS} is the DC bus voltage (V), $P_{B(t)}$ is the battery input/output power and Δt is the simulation time step, set to Δt=1h.
The size of battery storage can be calculated as follow [13]:

$$Batterystorage = 2 \times AD \times TDWU \tag{17}$$

Where:
TDWU is the daily watt-hours used;
AD is autonomy day ($1 \leq AD \leq 5$)

2.4. Distribution system

Figure 5 below shows the simplified distribution system of the low voltage DC microgrid system

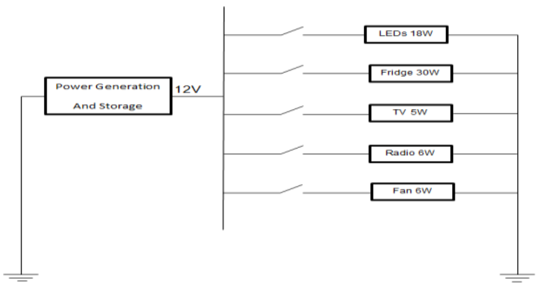

Figure 5. DC Distribution System

The wire sizing has to comply with the South Africa National Standard (SANS) on the wiring of premises. $6mm^2$ for the generation and storage side, and $2.5mm^2$ for the distribution side will allow an acceptable tolerance of voltage drop for this low voltage system, refer to SANS 10142-1 [14]-[15]

3. Simulation results

The BP solar BP3230T was selected based on the power demand and climatic conditions of the area retained for simulation purpose. The BP3230 has 60 series connected polycrystalline silicon cells. The key specifications are shown in Table 6.

Table 6 Key specification of the BP3230 solar module [16].

No	Parameter	Value
1	Maximum Power (P_{max})	230W
2	Voltage at P_{max} (V_{mpp})	21.1
3	Current at P_{max} (I_{mpp})	7.90A
4	Short circuit current (I_{sc})	8.40A
5	Open circuit Voltage (V_{oc})	36.7V
6	Temperature coefficient of I_{sc}	(0.065±0.015)%/°C
7	Temperature coefficient of V_{oc}	-(0.36±0.5)%/°C
8	NOCT	47±2°C

The 8A8DLTP-DEKA lead acid was selected as a means of energy storage. The key specifications are shown in Table 7.

Table 7 8A8DLTP-DeKA battery key specifications [17].

No	Parameter	Value
1	Nominal Voltage (V)	12V
2	Capacity at C/100	250Ah
3	Capacity at C/20	245Ah

To extract maximum power from the solar PV panel, the EPSOLAR tracer 2215RN has been selected as a MPPT solar charge controller. This MPPT solar charge controller has a peak conversion efficiency of 97% and a high tracking efficiency of 99%. [18]

The climatic data of Mthatha in the province of Eastern Cape is used in this paper for simulation. The hourly temperature data was obtained from the South Africa Weather service (SAWS) and the hourly solar irradiance data is provided by Helioclim through SoDa website [19]. An extract of daily average of sun irradiance and temperature over a summer day and a winter day was used to simulate the power generated by the PV panel.
The graphics below show the evolution of the power demand estimation and the power generated by the PV panel as well as the SOC of the battery. Figure 5 and Figure 6 show the results of simulation during a summer day.

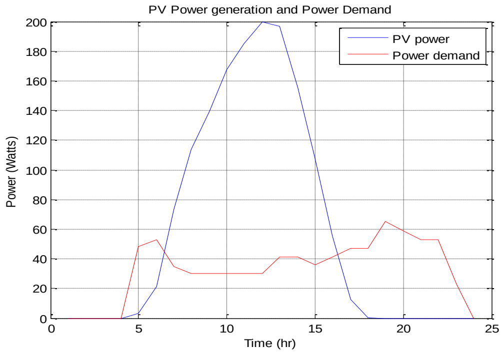

Figure5. PV Power generation and Power demand on a summer day

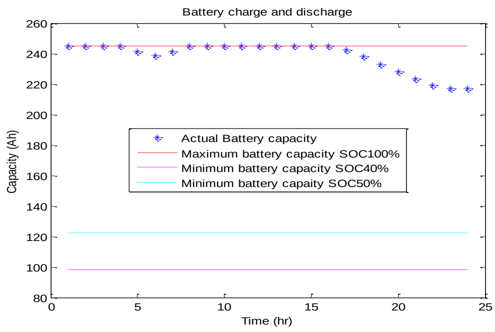

Figure 6. PV Battery charge and discharge on a summer day

Figure 7 and Figure 8 show the simulation results during a winter day

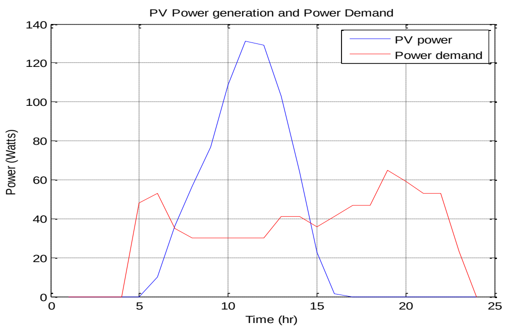

Figure 7. PV Power generation and Power demand during winter day

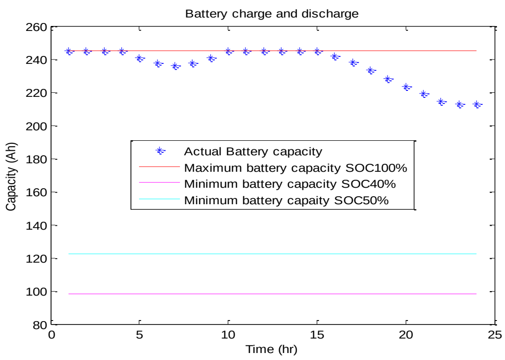

Figure 8. Battery charge and discharge during winter day

From the results of simulation we can see that the PV panel can sustain the power demand, and the excess of the energy generated by the PV panel will be stored in the battery, and will be used during no sunlight period. Also the discharge of the battery is above the two set minimum SOC (40% and 50%).

4. Conclusion

The design of a low voltage DC microgrid system presented in this paper offers an overview of a simplified solar system as a means of power delivery to households in rural outlying areas. This system is a good educational example tool for students interested in the design of DC microgrid systems for outlying areas. The importance and need for the use of renewable energy and cheaper technology in rural outlying areas were highlighted. A selection of energy efficient appliances based on the low-energy consumption restriction was presented. The proper sizing of the photovoltaic panel, the battery and the MPPT controller has been developed as well as the wires sizing. The simulations have been carried out and results presented show the efficacy of the designed system. Further work could include a low-energy cooking device and more detailed modeling of the system components.

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Indigenous Knowledge Systems

Stimulating Socially Relevant Computing through Community Engagement: an ODeL perspective

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Abstract

The low interest in computer science compared to other disciplines could be attributed to a number of students' perceptions, such as computer science being construed as complex and antisocial. A unique paradigm termed Socially Relevant Computing (SRC) is emerging to address some of the perceptions by focusing on engaging students in small projects that use computation to address challenges affecting their local communities. Nevertheless, the implementation of SRC at Open Distance e-Learning (ODeL) institutions faces a number of hurdles, mainly due to the mode of teaching and learning at such institutions. In this paper, we report on the research that investigated the value of community engagement in stimulating SRC amongst students at ODeL institutions. The preliminary results suggest that community engagement projects could be used for demonstrating the social relevance of computing and also attract students to the computer science discipline. The main contribution from this paper is a hackathon model that could be used at ODeL and other institutions to engage students in socially relevant projects and improve the computer science uptake. The model was developed through a case study conducted using an existing community engagement project at UNISA called Computing Pro Bono; which brings together different stakeholders to address social challenges using open technologies.

Keywords: *Socially relevant computing, Community engagement, Open distance e-learning, Computer science, case study, activity theory, hackathons*

1. Introduction

There is a steady increase in a number of student enrollments at tertiary institutions around the world [1]. However, this increase is not reflected in disciplines, such computer science (CS). In fact, in computer science students' intake has been low, especially when it comes to women and under-represented groups [2]. As a result, a number of strategies are being sought by researchers to stimulate interest in the computer science discipline. These strategies are meant to avert the negative economic, political, pedagogical, and social impacts that such decline could have in our communities at large. A number of reasons for the decline are also being studied, some of them including teaching and learning strategies, social relevance, and student awareness and understanding of computing courses [2, 3]. In [4], the decline in computer science enrolments is attributed to the notion that computer science is not offered as an idea that is socially relevant, important, and caring. It is further postulated that real world problems are lacking in undergraduate computing disciplines, thereby, making computer science not a priority alternative for undergraduate students, especially those who are altruistic and socially-aware [5].

At Open Distance e-Learning (ODeL) institutions, such as the University of South Africa (UNISA), the status quo with regards to interest in computer science courses is no different to traditional universities. However, ODeL universities are impacted even more by the declining interest in CS discipline, especially because of the mode of instruction and delivery, which is complicated by the notion of anytime, anywhere, equitable, flexible and democratized access. Students at such institutions are bound at some point to consider the misconceptions that computing courses are tedious and asocial [3], since they have limited opportunities to engage directly with their lecturers and communities in practical projects that offer real-world experiences and engaging challenges [6].

A Socially Relevant Computing (SRC) paradigm is emerging both in ODeL and traditional universities to stimulate interest in computer science by engaging students in projects that address social challenges that affect them and their local communities [7]. The emphasis in SRC is on learning computing for a cause. Since community engagement is one of the key performance areas at universities, we posit that there is a strong interrelation between SRC and community engagement. However, the implementation of SRC at the university level, especially in ODeL environments is a non-trivial matter. This is mainly because students are not bound by distance and time. Thus, in this paper we report on the value of community engagement in stimulating SRC at ODeL institutions. The research study was conducted following a case study approach using a community engagement project called Computing Pro Bono.

The rest of the paper is organized as follows. Section 2 provides background information relating to SRC and community engagement. Section 3 explains the rationale behind the research approach employed for the research study presented in this paper. The case study conducted using the Computing Pro Bono project is described in Section 4. In Section 5, preliminary results of the case study are presented and discussed. The main contribution from this paper, which is a hackathon model, is presented in Section 6. Section 7 concludes the paper by focusing on key findings and further research work.

2. Background

This section provides background information on the core concepts that underpin the study presented in this paper, and these are the socially relevant computing and community engagement.

2.1 Socially Relevant Computing

Socially Relevant Computing (SRC) is generally presented as an emerging paradigm with the main objective being to reinvigorate students' interest in computer science [7]. This concept focuses on the use of computation to solve social and humanitarian problems that engage students in projects that are both interpersonal and communal. The central vision of SRC is to improve the quantity, quality and diversity of students in computing disciplines.

This paradigm is quite common in social sciences, education, and health-related professions; where the design of complete systems commences from socially related problems [8]. Nevertheless, SRC requires a different approach to computer science instruction ranging from problem representation and modelling, addressing the key concepts of computer science and the pedagogical order in which to cover them [5]. This new approach according to [5], teaches students how to learn about new domains, how to work effectively in teams with scientists from varying disciplines as well as how to evaluate the social or ethical aspects of their solutions. This is very important as students should in addition to possessing significant technical skills also be able to assess the societal impact of their work, commit to standards of professional ethics and obtain the life skills necessary to undertake on-going professional development in their discipline [9]. Adding a social relevance dimension to the computing curriculum addresses the challenge that computing students are not sufficiently prepared for design challenges that manifest in their industry careers [5].

The Computer Science and Engineering Department at the University of Buffalo in America adopted the use of socially relevant projects into their design courses for Computer Engineering students in the area of assistive technology for the disabled [8]. Examples of the projects they worked on included an augmentative communication device for the speech-impaired, an interactive sensory system, which helps children with developmental disabilities learn choice making skills, and a single click user interface enabling quadriplegics to use computing devices. As may be ideated, some of these projects have strong foundations in demonstrating various theories and problem solving methods that are introduced to students in the computer science discipline.

A number of benefits were noted from these projects including the refinement of students' technical and non-technical skills, the generation of interest from prospective students, the revitalization of students and the embracement of interdisciplinary experience [8]. By working on these real-world problems, students acquired a sense of importance, motivation, and philanthropic energy [5].

Despite the noticeable benefits of SRC emanating from the case studies conducted by respectable universities and industry stakeholders, such as the University of Buffalo and Microsoft, the all-embracing implementation of SRC within universities across the world is deficient [6] especially in ODeL environments. In this paper, we focus on presenting community engagement as a possible approach for stimulating SRC, particularly at ODeL institutions. Community engagement, as discussed in the next subsection, provides a suitable environment for students to participate social projects that can be deployed and used in real-life settings.

5.2 Community Engagement

Community engagement is one of three core responsibilities of higher education, together with research and teaching [6, 10]. The Council of Higher Education further adds that in South Africa there are clear policy directives stating that community engagement is an important activity for academics and students [10].

In brief, community engagement refers to *"initiatives and processes through which the expertise of the institution in the areas of teaching and research are applied to address issues relevant to its community. Community engagement typically finds expression in a variety of forms, ranging from informal and relatively unstructured activities to formal and structured academic programmes addressed at particular community needs, and some projects might be conducive towards the creation of a better environment for community engagement and others might be directly related to teaching and research"[11]*.

The UNISA community engagement policy further posits that community engagement projects should *"enhance teaching and learning by producing socially responsible graduates that are also well suited to participate in a professional life whilst simultaneously addressing developmental challenges in communities"* [11]. It is because of such a statement that we perceive community engagement as one possible approach for motivating interest in computer science by both undergraduate students and secondary school learners.

3. Research Approach

An exploratory case study approach [12]; supported by document analysis, direct and participant observations, and open-ended interviews was used to collect research data used to develop conclusions and the proposed model as presented in Section 6. The case study method was chosen because of its "ability to examine in-depth" a phenomenon within a real-life setting [12]. Moreover, the case study was preferred as it provides opportunities to collect data using multiple sources of data [13].

In the context of our research study, the key unit of analysis was to understand the value of community engagement projects in stimulating SRC and possibly reinvigorate students' interest in computer science. In addition, the dynamics involved in the community engagement project that formed part of the study were also analysed, focusing mainly on the involvement of computing students.

The single case study (as described in Section 4) was designed within an existing community engagement project, called Computing Pro Bono. The case study was conducted and administered over a period of 6 months. The major component of the case study focused on direct and participant observations, where rich research data was collected. During the case study period, limited open-ended interviews were also conducted with purposely selected participants. The participants in this regard were mainly computing students, who participated in some of the community engagement events. Informal interactions with external stakeholders and seasoned professionals also informed some of the elements that compose the proposed model.

The case study evidence was analysed using thematic analysis and activity theory [14]. Thematic analysis "focuses on identifiable themes and patterns" of activities from research data [15]. On the other hand, activity theory provides a suitable conceptual framework for analysing collective work [16], and at the same time for understanding human activities within a specific environment (e.g. community engagement project). The case study is detailed in the following section.

4. Case Study – Computing Pro Bono

The case study that informed this research was undertaken within a project called Computing Pro Bono. This is a community engagement and outreach initiative in the School of Computing at the University of South Africa. The main objective of the project is to exploit the expertise of the computing staff, students, external stakeholders (e.g. professional developers), and subject-matter experts to develop open computing solutions that have the potential to address social and humanitarian challenges affecting local communities. It should be noted that the project also encourages inclusive participation, thus not only computing students could participate, but even students from diverse disciplines with different skill levels.

The central activities in the project are events referred to as hackathons. These are marathon coding events that bring together different stakeholders to build quick and yet fully operational prototypes that address social challenges within a particular domain [17-19] using both machine and human computation. The emergence of hackathons date back to 1960, however, their extensive use within the software development domain started to emerge in the 90's when the use of computer software became significant. Today, hackathons are a norm in large organizations such as Facebook, Yahoo, Google, and Microsoft. These events are hosted in these large organizations for many reasons, such as to build new solutions, to empower a community of developers, to entice developers to embrace latest technologies, and to recruit bright software developers into these organizations. In our context, they were organized to contribute in addressing social challenges in our communities using existing technologies (e.g. mobile devices) and also to understand their (i.e. community engagement projects) impact in reinforcing the social relevance of computing amongst students.

For the case study, we organized and hosted two hackathons in June 2012 [20] and December 2012. The events that we organized and hosted attracted over 100 participants including computing students, subject-matter experts, researchers, analysts, developers, and local stakeholders, who gathered and collaborated to tackle different social challenges in various domains, for example, education, service delivery, water and sanitation, unemployment, crime, and others. The participation in these events was voluntary and opened to both online and in-person attendees, although a majority of participants opted for the latter option.

Each event lasted two days (Saturday and Sunday). The events were planned for the weekend in order to attract a sizeable number of professional developers who are unavailable during normal working days.

5. Findings and Discussion

In this section, we present and discuss the significant findings that emerged from the case study using thematic analysis and activity theory as explained in Section 3. In terms of thematic analysis, a number of common themes were derived from the research data and these are discussed in conjunction with the same data that was analysed using activity theory. Briefly, activity theory focuses on six elements when analysing human activity, and these are (1) objects, (2) subjects, (3) community, (4) division of labour (5) rules, and (6) tools [14]. As explained, the key unit of analysis for the defined case study was to understand the value of community engagement projects in promoting socially relevant computing amongst computing students in an ODeL university. The results are discussed according to the derived themes (i.e. *challenges, participants, collaborations, technologies, and mentoring*) and based on the elements defined by the activity theory. The themes emerged from observations and interviews.

5.1 Challenges

In all hackathons, the main activity was about delivering computing solutions within a short period of time focusing on addressing identified social challenges. Based on the activity theory, *objects* are equivalent to challenges. These are the intended activities that role players engage with to achieve a particular outcome [14]. Some of the challenges that were tackled during the hackathons included projects, such as social informant, water detective, water pump monitor, micro worker, donate-my-school-stuff and many others. Most of these projects focused on providing mobile solutions, for example in the water detective project, methods were designed and developed on how to track water usage or shortages using mobile devices in rural communities. Details on some of these projects can be found on [21]. These challenges were presented by different stakeholders, such as non-governmental organizations, private and public schools, subject-matter experts. The challenges presented integrated a number of computer science concepts, such as searching algorithms, graph theories, and others.

During all the hackathons, it was also observed that although the main activity was about software development, other sub-activities were also performed by non-technical or novice participants, such researching on the presented challenge, gathering requirements from subject-matter experts, managing the to-do tasks list, and designing of user interfaces. During the events, it was directly observed that students do not normally present challenges, but contribute to solutions for various challenges. Most of the challenges presented offered students opportunities to apply what has been learnt in class in practice, do further research on computer science and information systems' concepts, reflect on various concepts in practice, and in some way confront social good issues in a collaborative environment.

5.2 Participants

The challenges presented in the hackathons were normally addressed in teams of about 2-8 members. The participants, which are referred to as *subjects* in the activity theory [22], came from different fields and had different skills sets, which was not only limited to technical programming. From the data collected, it became apparent that the subjects were instrumental in making the hackathons successful, particularly the subject-matter experts, developers, and organizers. It was observed that students engaged heavily with experts in the beginning, mainly for purposes of understanding the social challenges and possible approaches to addressing the challenge. These students brought a lot of dynamics into different challenges as they were open-minded, and attended these events to "*learn, and also practically apply what [we] have learnt in the classroom*" says one student. Most of the students interviewed find the whole concept of community engagement, especially Computing Pro Bono very useful, giving them a chance to learn from expert developers, but also an opportunity to be part of project teams that are capable of delivering solutions within a short space of time, using a number of open source technologies.

5.3 Collaborations

In all the hackathons that formed part of the case study, the aspect of *community* and collaborative work was central. In a number of instances, communities were formed before the events, either for problem finding and formulation or for identifying stakeholders that might benefit from the proposed solution(s). The challenges, although many required technical solutions, were tackled by appreciating all the contributions and diverse skills of individuals who participated. In this instance, students found the opportunity of addressing some of these challenges with others intrinsically rewarding. One expert asserted: "*students not only get the opportunity to understand the value of computer science in terms of social good, but they also get the opportunity to engage with industry professionals and subject-matter experts, who have already passed they road that they are currently travelling*". It should also be emphasized that by being part of collaborative teams, students also exposes themselves to *mentoring* and work integrated learning opportunities; which are sometimes limited within an ODeL environment.

Community engagement encourages the notion of "*working together to achieve more*" and we believe that students' participation in such projects is vital for their social and practical understanding of computer science concepts.

5.4 Structure, Rules, and Technologies

From the case study, it became apparent that the activities within the projects are somehow semi-structured, with participants, especially students deciding where they would want to be involved, for example, which challenges they want to contribute into or learn from. In addition, there are unwritten rules that govern how teams engage in activities. Normally, subject-matter experts would drive the requirements of the social solution meant to address the identified challenge. On the other hand, seasoned developers would lead the manner in which the development of the solution will be approached, such as what software development methodologies are used and which technologies are useful and relevant for the challenge?

Students would normally be tasked with setting up the environment, such as the relational database, designing simple user interfaces, and performing project management duties. However, depending on the technical skills of the student, more challenging tasks could also be distributed. However, it should be noted that for the two hackathons within the case study, the main objective of involving students was to expose them to the social side of computing and understand the value of community engagement in stimulating socially relevant computing.

Activity theory postulates that *subjects* engage with the *object(s)* by using different types of tools [23]. Open and mobile technologies were dominant, mainly due to the fact that they are easily accessible, easy to use, and normally receive wide support from the open source communities. It is also worth noting that mobile devices are quite efficient as experimental tools for testing various computer science concepts. This is because they have similar capabilities as traditional computers, such as network access, processing, and storage.

Nevertheless, it became evident during the interviews with some students that a technology choice was based on previous experience, awareness of the tool, and availability of online resources about the technology (e.g. documentation and tutorials). In some instances, it was also based on what the team deemed as appropriate for prompt implementation. In some cases, teams chose a technology that they had little working experience in. This as explained by the team was for purposes of "*trying things out*".

From the research findings, it is apparent that SRC has the potential to promote the culture of applying what is learnt in a classroom within a real-world setting, thus enabling students to acquire real-world experience without necessarily being in the formal employment or business sector [7]. At the same time, community engagement projects following the hackathon approach and other collaborative approaches are therefore a potential environment where students could be motivated to understand the social relevance of computation. The following section presents a suggested hackathon model that could be used as a foundation to stimulate socially relevant computing within an ODeL environment.

6. Hackathon Model

From the results of the case study conducted as described in Section 4 and Section 5, the preliminary hackathon model as depicted in Figure 1 was formulated. The purpose of the model is to stimulate SRC at ODeL institutions by involving computing students in community engagement projects that address social and humanitarian challenges that have a direct impact in local communities. The model is composed of various integrated elements, with the root element being the *computing curriculum*, where computer science theories are introduced to students. Some of these concepts could also be introduced to learners at primary and secondary level, similar to other disciplines such as physics and chemistry.

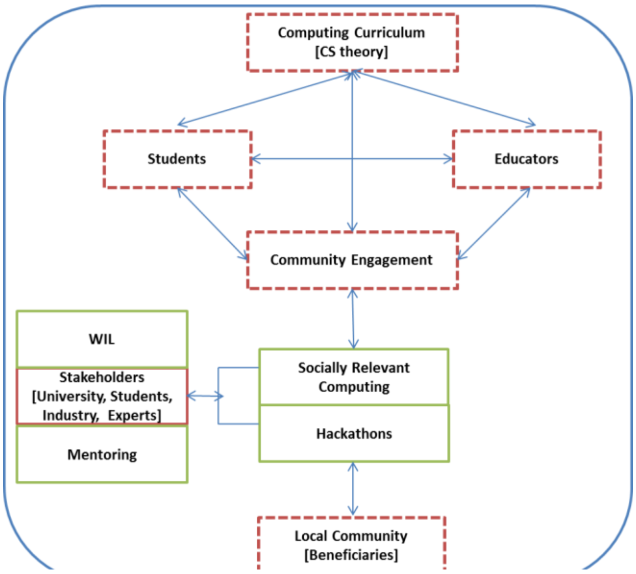

Figure 1. Proposed hackathon model to stimulate SRC

As it may be noted in Figure 1, the introduction of computer science concepts to students is managed by educators. However, this process should be synergistic, where students and educators continuously engage through various pedagogical strategies for purposes of promoting better learning and understanding. Within this element, it is also important to start reflecting on the social importance and impact of computer science, possibly through small and social class-based projects.

A direct connection between theory and practice need to be formulated as well, using new or existing community engagement projects. These projects would probably differ from time to time. However, the focus should be on addressing social challenges using computation. The process of aligning the curriculum with community engagement projects is a process that needs to be given enough attention, and improved over time through experience and participation by both students and academics.

The defined community engagement projects should also be utilized to progressively introduce the concept of socially relevant computing through different types of events, such as the hackathons to computing students. The purpose should also be to provide students with opportunities for work integrated learning through external stakeholders that participate in the hackathons. Mentoring as an approach for engaging and guiding students in a specific area should not be ignored. Students should also be encouraged to engage with professionals, subject-matter experts, and local communities, especially in understanding their value in using their disciplines for social good.

The ultimate goal of reinforcing the social relevance of computing curriculum through community engagement project should be to address social challenges affecting local communities. The model is still at its infancy stage and is continuously being improved as we shape computing curriculum through various computer science modules that we are involved in at the university.

7. Conclusion

In this paper, we have demonstrated the possibilities of reinforcing the social relevance of computer science using community engagement projects amongst ODeL students. Community engagement projects provide a number of possibilities and opportunities for students and academics. In our context, the projects were executed in a form of hackathons. The potential of hackathons in delivering socially-relevant computing solutions within a short space of time is self-evident from the case study conducted.

The main contribution from this paper is a proposition of a hackathon model as one possible approach for encouraging students' involvement in solving social pressing issues affecting communities using the socially relevant computing paradigm as a foundation. The model is composed of various elements. The alignment of *computing curriculum* and *community engagement* projects, such as Computing Pro Bono are some of the parts of the model. Furthermore, involvement and participation of both the academics and students in these projects plays a major role in promoting socially relevant computing. Although, the model focuses on SRC and community engagement, other possibilities emerged from the findings, such as mentoring and work integrated learning opportunities for students through external stakeholders. Further research work points to the replication of the study with more computing students and the evaluation of the model in other environments, such as traditional university. The efficacy of the proposed model in addressing the low interest in computer science also requires further investigation.

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Presenter: The paper is presented by Dr Jabu Mtsweni

Computational Intelligence and Computational Science used toward a Postal Information Systems Strategy

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Abstract

The wide spread use of email and other forms of Internet communication has contributed to a significant decline in the traditional letter-mail business. Globally, postal operators are responding by providing a range of new e-services. The Universal Postal Union has defined 55 postal e-services and studied the extent that they have developed across their diverse member countries. This research examines the use of computational intelligence and computational science to make 1) e-post and e-government more effective, and 2) improve the competitiveness of traditional post delivery. Information systems and information technology (IS/IT) must play a significant role in shaping a postal service's business strategy. All organizations are confronted with vast quantities of data and information that must be processed to make the most effective decisions. The postal service is positioned to effectively use computational intelligence and computational science to convert this information into knowledge constructs. With its well-established global connectivity, postal services are positioned to become more productive.

Keywords: *computational intelligence, e-services, computational science, Post Office*

1. Introduction

An increase in productivity due to technology advances means fewer people are required in the mining, agricultural and manufacturing sectors. The increased complexity of these sectors has led to more service jobs. Of particular significance is the increase in information systems / information technology service jobs. Also the trend of increased productivity has led to increased consumption. Much of this consumption is in services. This has led to an increase in service occupations and new services. Also, it has caused significant changes in traditional service industries such as the post office. The extensive use of email and other forms of internet communication have contributed to a decline in traditional letter-mail business. Many post offices have responded by providing a range of new e-services.

This research examines best practices and recommends the use of computational intelligence and computational science to make 1) e-post and e-government more effective, and 2) improve the competitiveness of traditional post delivery. Information systems and information technology (IS/IT) must play a significant role in shaping a postal service's business strategy. All organizations are confronted with vast quantities of data and information that must be processed to make the most effective decisions. The postal service is positioned to effectively use computational intelligence and simulation to convert this information into knowledge constructs. With its well-established global connectivity, postal services are positioned to become more productive.

2. Public Services and Public Policy

The pressure from labor and communities has led to governments enacting public policies that create new and expand existing services. This has been an important aspect in the ongoing changes in the service sector.

> "Our proposition is that in developed countries in socially important areas like health, education, welfare, and security (HEWS), where there exists differential information in favour of the producer, responsibility for progress is necessarily on the agenda of government, in the public domain, and the service delivery activities of the professional specialists in these areas is properly structured not by the market system, but by institutions of social responsibility, like legal regulations, civil law, and a rigorously grounded, well understood and properly enforced code of professional ethics."[1]

It has been recognized that government has a particularly critical role in setting policy in developing countries. Policies that allow the post office to engage not only in e-post services but e-finance, e-government and e-commerce take advantage of the existing postal system infrastructure. This infrastructure is built on years, sometimes centuries, of person-to-person communication that is the core of the post office business.

Dunleavy et al [2] argues that public administration and management has lost sight of the fact "that bureaucracies are socio-technical systems; and that the organization of information-processing is key to bureaucratization pushing ahead (for better or worse) the modernization and rationalization of human conduct." If government can overcome this short sightedness it will establish policies that promote e-service development through the post office. Without such policies, e-service development will be left to the unregulated market system. This will further empower the strongest information technology and information system enterprises and likely extend the digital divide.

> "It is necessary, but not sufficient for government to set e-service policies that are favourable to the public sector. Government must constantly recognize citizens as the customers and incorporate citizen inputs into decisions. "The key for successful technology innovation in the public sector is to add interactive features, provide for greater customization, and incorporate visitor feedback in agency operations. Government departments need to become more collaborative in their decision making processes. One of the reasons why the private sector does well on technology innovation is that businesses pay attention to their customers and draw on the experiences and expertise of visitors to their websites. Taking advantage of citizens' judgements is a great way to leverage outside knowledge. Involving more people in key decisions would help the public sector become more innovative and entrepreneurial [3]."

The public sector must learn from the best practices of the leading innovators in the private sector. These innovators pay close attention to customers' experiences and perception. West [3] highlights five keys to effective innovation.

> "First, successful adopters must devote sufficient resources to the innovation process … Second, successful innovators focus on the customer, value market research, and take visitor feedback seriously. … Third, technology innovators provide incentives for management and design teams to work together. … Fourth, innovators devote time to understanding their competition and determining how to position themselves vis-à-vis market competitors. … Finally, successful innovators tie resource allocation to customer satisfaction. Ultimately, there must be clear consequences that result from effective or ineffective technology innovation."

2.1 Information from Universal Postal Union

Information and communication technology (ICT) has drastically changed the face and operations of public services. This is most apparent in the postal service. Postal service is one of the most entrenched national services with global connectivity. The Universal Postal Union coordinates this global connectivity. Established in 1874, the Universal Postal Union (UPU) has 192 member countries. The wide spread use of email and other forms of Internet communication has contributed to a significant decline in the traditional letter-mail business. Globally, postal operators are responding by providing a range of new e-services. UPU refers to postal electronic services (e-services) as "services, delivered by Posts to their end customers through information and communications technology (ICT) channels [4]." The UPU has defined 55 postal e-services and studied the extent that they have developed across their diverse member countries. These e-services are divided into four categories: e-post, e-finance, e-commerce, and e-government. Table 1 is a list of the e-post codes and services. Table 2 indicates the e-government codes and services considered in the UPU study.

Table 1: e-Post Codes and Services

Services Code 101 to 110	**Services Code 111 to 120**	**Services Code 121 to 129**
Public Internet access point in post offices	E-cards	Electronic notification to Post of letter needing to be collected
Web information on services and tariffs	Online burofax	Electronic notification that letter is to be delivered, to addressee
Postal electronic mailbox	Hybrid mail (electronic to physical)	Electronic notification to sender that letter has been delivered
Online direct mail	Hybrid mail (physical to electronic)	Electronic notification to Post that parcel needs to be collected
Postal registered electronic mail	Postcode lookup	Electronic notification that parcel is to be delivered, to addressee
Electronic stamp	Postal address validation	Electronic notification to sender that parcel has been delivered
Customized electronic stamps	Post office location lookup	Check mailbox contents online
Electronic postal certification mark	Address change online	Web-based customer service and contact
Electronic signature	Holding of mail delivery online	Applications on mobile devices
E-telegram	Track and trace	

Two major findings of the UPU study are 1) “Postal e-services are growing globally, but there is a divide between industrialized and developing countries” and 2) “Innovation capability influences the development of postal e-services more than wealth does. … innovation capability as well as the development of regulation and infrastructure related to ICTs are factors supporting the development of postal e-services [4].”

Table 2: e-government Codes and Services

Code 401 to 406	**Code 407 to 411**
Digital identity	Management of patients’ electronic medical files
Driving licence renewal	Electronic medical certificates
Online shopping tickets: cultural and/or sports events	Electronic collection of public medical fees
Electronic university registration	Electronic export documents
Electronic payment of retirement pensions	Electronic customs documents
Online passport application	

2.2 Best practices from UPU report and sites from best Post Offices

This UPU study represented their first attempt to measure the development of postal e-services in UPU member states. It required the UPU to develop a measurement index. They used principal component analysis (PCA) to develop indices for e-post, e-finance, and e-commerce. Then PCA is used to combine these three indices into one postal electronic services index (PES index). Table 3 ranks the top ten UPU countries based on the PES index. The UPU looked into a range of factors that could possibly influence the development of postal e-services and concluded that the most significant factors were 1) innovation capability of a country, 2) the development of its telecommunication infrastructure and 3) the development of regulations related to e-services.

Table 3: Top 10 countries by PES index

PES rank	Country name	PES index	e-post rank	e-finance rank	e-commerce rank
1	Switzerland	4.32	2	1	2
2	Belarus	4.09	5	2	1
3	Italy	3.45	7	4	9
4	Germany	3.23	8	8	3
5	Qatar	2.98	3	10	3
6	Tunisia	2.85	15	5	8
7	France	2.65	1	19	22
8	Korea (Rep.)	2.43	4	17	23
9	United States	2.36	6	47	5
10	Canada	2.28	14	9	12

UPU did not include online government services as a component of the PES index. However the study does provide the index for online government services for its member countries. The top 12 are listed in Table 4. The countries with the highest levels of online government services and highest PES indices will be examined in more detail to identify best practices.

Table 4: Top 12 countries by online government services

Rank	Country	Rank	Country
1	Korea (Rep.)	7	France
2	USA	8	Sweden & Denmark
3	Canada	9	Singapore
4	United Kingdom (UK)	10	Germany
5	Australia	11	Switzerland
6	Spain	12	Austria

Even leading postal services face an uncertain future. According to the Boston Research Group report on USA postal service:

> "The USPS will require significant structural changes to avoid staggering losses in the coming decade. The magnitude of these losses will require a combination of robust cost reduction actions, including changes in delivery model, including days of delivery and service standards; changes in network, including closing branches and integrating post activities into other retailers' footprints; and changes in labor cost structure" [5].

The government in the USA has enacted policies that limit the Post Office's ability to engage in a range of e-services. The responsibility of e-government is divided among a number of government agencies. Policies restrict the Post Office's ability to engage in e-finance and e-commerce.

2.3 South African Postal Services

South Africa has a PES rank of 21 and a PES index of 1.26. This is the 2nd highest (behind Tunisia) of African countries in the UPU study. In an effort to extend its online presence, the South African Post Office recently announced the development of the Trust Centre, "a highly secure environment that holds the public key infrastructure (PKI) and Certificate Authorities (CAs) which provide user authentication and ensures trust and legal status in electronic transactions through the use of Trust Centre digital Certificates"[6]. The South African Post has a network of 2600 outlets. The SAPO is the most active postal service in southern Africa. The South African Post Office delivers mail items each work day to almost ten million addresses. The South African Post Office delivers to an area of more than 1.2 million square kilometres - an area larger than Austria, Belgium, France, Germany, Luxembourg, Switzerland and the Netherlands combined. With more than 2 400 outlets and 5 500 service points, the South African Post Office has the largest reach of any organisation in South Africa. "Mail Business boasts 25 mail sorting centres for domestic mail and parcels including 3 international sorting centres for international mail and parcels. Between these centres, approximately 6 million mail items are handled daily and 50 tons of parcels are processed per annum" [6]. The SAPO is positioned to play a leading role in advancing postal services across Africa. Innovation and effective information systems strategies are essential to achieving the goal of high quality postal services across Africa.

3. Computational Approaches to improving services

Computational techniques are used to analyse the service operations, as well as the vast amount of data and information collected from observing service operations. Operations research offers a wide variety of techniques such as mathematical programming, regression analysis and forecasting that can be used to optimize resource allocation and system element location. Simulation, as well as, systems thinking approaches like system dynamics, can be used to improve service delivery.

3.1 Select Approaches in Computational Sciences

The most effective deployment of Post Office resources can be addressed using mathematical programming techniques including linear, integer and non-linear programming [7]. These can be used to determine the location of postal pickup boxes, post offices, regional distribution centres and vehicle depots [8]. These techniques can also be used to facilitate scheduling of mail pickup, mail delivery and personnel.

Discrete (computer based) modelling and simulation is a standard component of Mathematics, Engineering and Computer Science curriculum [9]. Discrete simulation is an effective way to study a number of the postal operations. In particular, the discrete simulation of proposed post offices based on data from similar existing post offices can be the basis for most effectively designing and setting up new post offices and reorganizing existing ones. The standardization of many of the postal operations and the similarity between post office operations across a country make this a particularly appealing technique. The data and information collected from previous postal activities is a reliable source for modelling the distribution functions associated with proposed simulation models.

System dynamics is built on the mathematics of differential equations. The causal relationships in a real or hypothetical system are quantified to reflect a set of differential equations [10]. The system dynamics development system greatly simplifies this development process allowing the user to focus on the feedback loops identified as being critical to the operation of the system. Critical to the implementation of the system dynamics approach is the identification of key variables and the patterns the values of these variables form over time [11] [12]. The computer uses numerical analysis techniques and difference equations to approximate the results of a set of differential equations. The simulation time frame spans past time periods as well as the future. The results of these simulation models are compared with the historical values of the key variables as a check on model validity. This system dynamics approach has proven useful in the study of a number of global and environmental systems [13][14]. The patterns of the reduction in traditional mail and the increase in e-services can be modelled with a focus on identifying the causal relationships and the feedback loops. An effective closed loop model will allow a study of the policy options available to the Postal Office. This will be a very useful tool for postal decision-making.

3.2 Select Approaches in Computational Intelligence

Data mining is employed to get useful information and knowledge patterns form megabytes of information collected over years on mail traffic and other postal activities [15]-[17]. As the Post Office gets more involved in electronic activities a much larger volume of information and data is collected. Data mining techniques will become more important with this increased volume of information being processed.

One of the best ways of reducing the digital divide in e-services between post offices in different countries is to quickly employ the best practices from the highly PES ranked countries in developing countries. This can be facilitated by incorporating these best practices into expert systems [18]-[20]. The expertise of the best postal operators and postal operations will be transferred to software that can easily be transferred, duplicated and used in multiple locations.

Early work with ‘internet of things’ focused on sensors and actuators throughout the home connected through a wireless network and operational both, within the home and remotely [21]. It has an appeal to a large audience of homeowners. Also, referred to as the ‘internet of industry’, a much wider range of equipment, products and locations can be networked [22] [23]. Scenarios with products, equipment and people networked across cities, nations and even globally are in the making. The Post Office can use this technology to track trucks, packages and workers. Data collected in a range of situations over time can be used to adjust schedules, routes and allocation of resources to increase efficiency. Important issues must be addressed concerning employee and customer privacy [24]. Issues of personnel and mail security must also be taken into account. Efficiency must be achieved without the loss of security and privacy.

4. Methodology

This study uses a systems approach combining value chains and historical materialism. This approach is designed to formulate a multidisciplinary framework for connecting university education and research with the postal service industry. The initial effort is to engage universities in Southern Africa and Howard University in Washington, DC with the South Africa Post Office (SAPO). The understanding gained from value chains and historical materialism will be the basis for using computational intelligence and computational science to address the information systems strategy of the SAPO.

Historical materialism applies the dialectics of materialism in a social context identifying the tension between the 'forces of production' and 'relations of production'. The forces of production are the people involved in the production or service generation combined with their skills and the equipment and facilities at their disposal. The relations of production address the ownership and control over the facilities, equipment and resources involved in production, as well as the distribution of the products, services and profits from the work done [25]. This is more straightforward when manufacturing and selling products. For example, in an automobile factory we have workers, levels of management and owners of the factory. The owners control distribution of products and the profits from the production process.

For the service sector it is more complex. The service sector itself is very diverse from security services, information technology services, financial services, educational services, health services, to postal services. Some of these services operate as independent for-profit enterprises while others are government controlled and/or not-for-profit services. Government controlled services are often funded through government taxes such as basic education and public libraries.

Value chains examine the life cycle of a product or service with a focus on the value added at each point and the cost and benefits to the different stakeholders in the process. Value shops and value networks are special cases of value chains that are particular relevant to the examination of services such as the Post Office.

5. Results and Discussion

Based on the best practices of countries with the highest PES indices, four e-post and four e-government services were identified. They are the focus of expanding the offerings of SAPO. In selecting these eight services, the impact on the broadest population was also considered. The focus e-services are shown in Table 5

Table 5: Focus e-services

Code	E-post service	Code	E-government service
101	Public internet at PO	401	Digital Identity
103	Postal electronic mailbox	405	e-payment of pensions
104	Online direct mail	407	Management of e-medical files
114	Mail (physical to electronic)	411	Electronic customs documents

In most countries, the postal service is a unique government entity that operates on the revenues derived through its various services. The postal service is a network service where the main function is to link one customer to another. A significant amount of mail and parcels are business to business transactions and business to the public transactions.

The relations of production in the service industry vary from service to service. For medical services the doctor or medical practice, owning the means of production, controls access to the medical services, sets prices and controls the profits. Government services that directly address the needs of people such as social security, passport processing and postal delivery require funding from the government instead of creating profits. The setting of wages and benefits for workers in these services is based on the organized power of the workers, the relative importance placed on these services by a broader public, as well as the pressure put on the state by the dominant class. In most of the world, the dominant class consist of wealthy capitalists. The capitalist ownership of large tracts of land, factories, farms and mines gives them the power to dominate in the government and public sector arena. While capitalists directly control the means of production in their factories, farms and mines, they indirectly control the means of production in the public services sector.

In general, capitalists support the market approach. This calls for minimum government involvement in providing services. Minimal government involvement means less funding for service workers, and their training, equipment and facilities. These are the forces of production. This reduced support reduces worker job security, as well as worker productivity. This in turn can make private sector attempts more profitable choices.

Fedex and DHL are examples in the global private sector parcel delivery service arena that directly compete with the Post Office. This has contributed to the decline in traditional mail services for the Post Office. For the Post Office to increase its role as a service provider, postal workers must leverage their power to influence policies that regulate traditional mail and parcel delivery and determine what new e-services the Post Office can provide. This is an example of indirect relations of production. Post Office workers must organize a larger base of workers and communities to get the government to set policies favourable to Post Office expansion. These policies allocate resources that expand the means of production for the post office. This expansion can be new technology, techniques and training that increase productivity. The expansion can also be a market expansion. The market expansion can be new services or and increase in the customer base using traditional services.

A better understanding of how the value chain of postal services functions will also allow the post office to organize itself to have a greater impact on policy decisions. Value networks are a special type of value chain.

> "Value Networks are businesses that provide exchanges and mediation between buyers and sellers, enabling relationships to be established. They earn revenue from either or both in their use of the firm's network 'everyone's a customer'. The UK's Post Office is an example both in its mail and parcel delivery and its counter services where it is acting as an agency for government service delivery (DVLC, Social Security, etc.). The services may extend beyond connection to revenue collection, contract management, systems integration, information source, etc., in terms of adding additional value for a customer or customer segment" [26].

Value networks consist of four components: 1) A set of customers, 2) Some service the customers all use, and enables interaction between the customers, 3) Some organization that provides the service and 4) A set of contracts that enables access to the service. The traditional postal services of mail and parcel delivery operate as value networks with a sending and a receiving customer and both should be effectively served. The postal electronic mailbox and physical to electronic hybrid mail operate as value networks. In each case the sender and receiver are customers benefiting from the delivery of mail.

Many of the added services at the Post Office, particularly many of the newer e-services operate as 'value shops'. "Value Shops are businesses that essentially are 'problem solving', delivering value by providing solutions for clients. They are characterized by intense and extensive information exchanges both in setting up the business transaction and delivery of the solution [26]." The e-government services of digital identity, electronic payment of retirement pensions, management of patients' electronic medical files, and electronic customs documents all should be considered value shops. The two remaining e-post services from Table V – public internet access point in Post Offices and online direct mail are both value shops.

The traditional postal services of letters and packages processed and delivered remain the primary function of the Post Office. It is important to address how to make these services more effective. A number of private companies have emerged to compete for national and international parcel delivery and same day intercity mail delivery. The post office must innovate or it will lose its market share in this shrinking service arena. The Post Office must leverage its well-established infrastructure, particularly its people, to use innovation to increase quality of service and reduce costs.

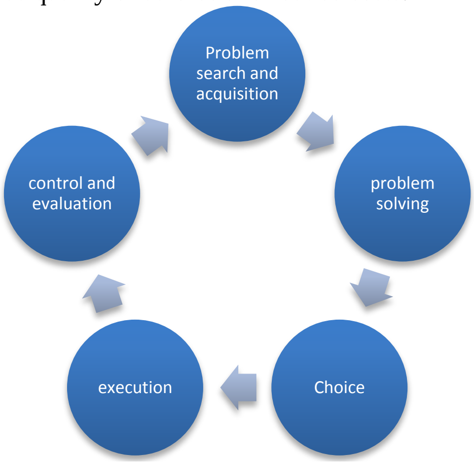

Figure 1: Value Shop diagram (variation from [27])

The use of computational science and computational intelligence to increase postal service efficiency can help empower postal workers. Simulation studies of the operations of post offices, as well as the post office competitors, will provide valuable information on bottlenecks and potential scenarios to increase quality. Optimization techniques such as integer programming should be used to improve resource location. Examples are the location of post boxes, postal stations, and distribution centres. Optimization techniques can be used to improve routes for delivery of services, as well as the allocation of resources (people and equipment) to the different postal locations. The demographics of local communities and nations are constantly changing. The Post Office information systems strategy must keep this in account in addressing not only recent demographic changes but planning for projected demographic changes well in advance.

Value shop services can benefit from the use of knowledge elicitation and expert system development because “In the Value Shop, Reputation is King. The better firm is the one that can combine the attraction of good cases with mobilisation of the right competence” [27]. Figure 1 shows the five stages of the value shop operation. Knowledge acquisition can be used to collect knowledge on each of these stages. The capture of best practices of existing e-government and e-post services can be used to implement rule-based and/or case-based expert systems. For example the e-customs documentation process can be implemented using an expert system. This would capture the best practices of a limited number of customs experts. The online access of the expert system would make the customs documentation process available to the broad population in user-friendly format. The various e-services must be setup to collect information on their utilization. This information should be structured in a knowledge management system. Data mining of this information should provide new insights on how to may the various postal services more efficient.

Marwala [28] explains how computational intelligence can be used to aid policy development. “The principle of correlation is important in policy formulation because correlations give us a diagnosis of what is happening in society.” Marwala goes on to indicate a “vital area in South Africa is the problem of service delivery and in this regard it is important to identify factors that could improve service delivery and relate such factors to service delivery. … It is evident that causality, correlation and artificial intelligence have a role to play to advance society.” Discrete simulation models provide a better understanding of the dynamic role of correlation. System dynamics models lead to knowledge regarding causality’s impact over time.

6. Conclusions

The eight identified key e-services should be addressed in the Post Office Information Systems (IS) strategy. The IS strategy should be an explicit component of the Post Office business plan. Linking information systems and information technology operations to the broader Post Office business plan is critical. This IS strategy must include the tools and training to implement computational intelligence and computational science practice in the optimization of postal operations. When the SAPO implements these new e-services, it will increase the viability of the postal service. These services will better inform and empower the country's citizens.

The study of computational intelligence and computational science using real world examples and potential scenarios from the postal service will be useful in better preparing students for knowledge engineering and computational analysis jobs in the postal service as well as other service industries. This is an important aspect of making the engineering curriculum more relevant. This is consistent with previous work linking appropriate technology and socially relevant computing to both undergraduate and postgraduate curricula [29]

A historical role of the post office has been to enhance communication among a nation's citizens. This communication has been empowering. Mail and parcels, and various electronic communications are connecting billions of people globally in the broadest sharing of information, knowledge and resources. This historical reality should serve as incentive for the Post Office to embrace innovation to improve the quality of service of traditional postal operations and aggressively expand to include other forms of media and service development and delivery. "Mining information to extract unique intelligence and create new knowledge must become routine. Continual analysis and interpretation of market, process, product, and business information are necessary to identify new areas of revenue growth and innovation [30]." The proposed curriculum and research collaboration between Howard University, Southern African universities and the South African Post Office will help achieve this continuous innovative environment.

7. Discussion and Future Efforts

This effort will be extended as part of the course content in an Information Systems Strategy course. The first author has taught this course during the past academic year at the National University of Science and Technology and plans to teach it again this year. This is a required course for all students in the Masters in Information Systems program. The course will be useful in preparing MIS graduates for assisting in enhancing Post Office services through their IS/IT strategy. A comparable course is being designed for use in South Africa. In both cases, it should improve students' ability to get attachment projects assigned to the Post Office.

New e-governance services should be considered by UPU and SAPO that would further empower a broader population. New services to consider are: 1) tax collection and rebates; 2) information on parliament/congress voting; and 3) information on government spending. These services could all be maintained through a government web portal. The Taxes service would allow a user to, after inputting identification information, get information on their taxes paid, taxes due and rebates due; post payments; and apply for rebates. Information on how taxes are used and tips on monitoring tax collection and tax spending should also be available. A dynamic web portal point can provide a history of governmental representatives votes on bills, positions on issues and funding received. This should enhance individual accountability and empower voters. A dynamic portal point that provides a history of government spending and spending under consideration will force more government fiscal accountability to the public. Assistance in accessing these services would be provided at the public Internet access points in the Post Office. This effort should be complimented with posters and other printed information at the Post Office and mailing to all potential voters.

The use of the evolving postal services provides a productive research environment for universities in both developed countries, like the USA, as well as developing countries like South Africa. The ongoing global collaboration through the UPU gives this important service industry even more potential to emerge as a leading player in the larger e-services arena. It is important for the universities to link other disciplines like public policy, political economy and management science to this academic and research agenda. This current research demonstrates the multidisciplinary nature of work to improve the quality of service and employ innovation to expand postal operations.

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About a method of educational web resources optimization

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Abstract

With continuous growth of information volumes in the web space, it is important to maintain one of the main purposes of the web service – to provide the necessary information to users conveniently. For educational websites, it is especially important during admission campaign. It explicitly impacts the number of students who participate in the enrolment contest. To make assumptions about the effectiveness of information retrieval, web analytics tools are used. However, we can find website navigation problems by exploring the hyperlinks between web pages on the basis of some mathematical models. We have applied both approaches in practice during the admission campaign in the technical universities of Saratov city. We analysed the visits' statistics for selected target pages, and made conclusions about demand degree users for it. For extended analysis, we constructed a mathematical model of hypertext structure and identified potential problems in it. The generalized results of the analysis of visits' statistics as long as analysis of the model of hypertext structure has formed the basis for further recommendations for re-engineering of the hypertext structure to help users in information retrieval.

Keywords: *Web Analytics, Hypertext Reengineering, Educational Web Sites, Discrete Models, Hypertext Semantics.*

1. Introduction

In the time of continuous growth of information resource volumes in web space, it is important to maintain the main purpose of web service – to provide the necessary information to users in convenient way. While retaining the simplicity and clarity of information retrieval, web site in turn should direct users to specific target pages that are relevant at the current moment.

For universities, the total number of students who have applied for admission and participates in the enrolment contest depends on results of admission campaign. That's why for educational websites the convenient information retrieval is very important during this period, because users' visits to target pages directly influence the efficiency of organization's website.

During life cycle of website the continuous growth of information volumes and increase of informative web pages proceed. In turn, due such intensive growth the link structure is complicated and it is lead to appearance of hard-to-reach pages, reducing of the whole hypertext structure effectiveness. Navigation becomes more complicated and entangled for users. [1] [2].

It is possible to reduce the negative impact of this process by the means of analysis and re-engineering of web site's hypertext structure. To perform such analysis, it is possible to discover problems and gaps in navigation structure, which reduce the number of page views by users. The results of analysis can be used as a basis to generate recommendations for re-engineering of the hypertext structure.

In this paper we present the approach based on combined using web analytics' tools and mathematical methods of discrete mathematics to perform analysis and optimization of educational website. The results of analysis presented in the paper are based on the real data gathered during admission campaign in the Saratov State Technical University (SSTU).

To perform analysis, we have manually allocated two groups of target pages on the SSTU website. The first ones, containing extensive information, which may affect the effectiveness of the admission campaign – these are pages of departments, faculties, student organizations, and so on. The second ones contain the general information about the courses and admission rules.

2. Analyzing web site's statistics

The main source of data about users' activity on the web site is the statistics of visits gathered by web analytics tools such as Google Analytics. It allows the exploring users' behavior and making assumptions about the effectiveness of information retrieval. Possibilities of applications for gathering and analyzing statistics of user behavior on the web site were studied widely. In particular, approaches to the definition of the interests of users considered in books of Clifton [3] and Kaushik [4].

It is well known, that web resources of education organizations play important role in business process. Thus, information placed on web pages influences on real institution's processes. One of such important processes is admission campaign.

So we analyzed statistical data including page visits and unique users' visits for first group of target pages to see how information presented on web pages of departments and faculties affects admission campaign, i.e. how it correlates with amount of enrollees on these faculties.

First of all, we gathered statistics of target pages' views from the beginning of admission campaign. To clarify data, we took into account only those visits which were performed from admission campaign page; visits of faculty-related department pages are not included. We also calculated which part of overall faculty pages visits presents each of target pages.

Then, we extracted data from admission campaign including amount of enrollees on each faculty. We also calculated a part of each faculty's number of enrollees' applications. Finally, we compared gathered web analytics' data with numbers of enrollees' applications in different dimensions. The results are presented in the Table 1.

Table 1. Dependencies between page visits and enrollees' applications

	Visits		**Applications**		**Apps / Visits relation**	**Ratio**	**Ratio's sq. dev.**
Construction, Architecture and Road Faculty	748	16,6%	574	17,7%	76,7%	94,0%	0,004
International Faculty of Applied Information Technologies	677	15,1%	333	10,3%	49,2%	146,7%	0,218
Faculty of Economics and Management	651	14,5%	430	13,3%	66,1%	109,3%	0,009
Faculty of Electronic Engineering and Instrumentation	577	12,8%	393	12,1%	68,1%	105,9%	0,004
Faculty of Ecology and Service	414	9,2%	399	12,3%	96,4%	74,9%	0,063
Faculty of Energetics	365	8,1%	380	11,7%	104,1%	69,3%	0,094
Automotive Faculty	330	7,3%	228	7,0%	69,1%	104,4%	0,002

Socio-Humanity Faculty	274	6,1%	206	6,4%	75,2%	96,0%	0,002
Faculty of Mechanical Engineering	268	6,0%	143	4,4%	53,4%	135,2%	0,124
Physics-Technical Faculty	190	4,2%	157	4,8%	82,6%	87,3%	0,016
Total	**4494**		**3243**		**Av. 72,2%**		**0,053**

To demonstrate the relation between number of page visits and number of enrollees' applications, we have calculated **Apps / Visits** relation. As can be seen from the table, for majority of faculties, this relation is close to the average value.

To make it more explicit, we can look on the **ratio** of concrete **Apps / Visits** relation for faculty to average value. It describes how much amount of page views for current faculty exceeds the average value. In simple terms, the higher is ratio, the larger is amount of visits and lesser the amount of enrollees' applications, and vice versa.

We can say that the ratio shows how page visits influence the admission process. The larger is ratio, the lesser is influence – that means that admission campaign for this faculty is less dependent on its pages' views. It is also important to pay attention on the deviation of the defined ratio. It shows that for some faculties the number of page visits is much higher than for others. So we can conclude that these faculties are more popular for web site visitors, and the data placed on corresponding pages affects admission process higher, than for other faculties.

Analyzing such data, it becomes clear that there is explicit correlation between the number of faculties' page visits and the number of real enrollee's applications which have been made during admission campaign.

Moreover, we can empower abilities of web analytics by examining at the same time the structural links between the pages of the website, as well as statistical data. Thus, we can get additional information about possible problems and errors that somehow could lead to the decrease in the number of visits of target pages, and as a consequence to reduce the overall effectiveness of a web resource.

3. Applying mathematical method

Previously we've proposed the mathematical methods for design and analysis of the model of hypertext structure of the web site, aimed at identifying the various features of the structure which may affect the attendance of its nodes by users [5]. So now we have applied developed techniques in practice.

Web statistics give wide abilities to perform web site analysis. In particular, using the accumulated data, we may compose an approximate user's view of the target pages on the web site: for example, defining them as the last page in the sequence of all of the pages visited by chosen user; or as a page, the time of visiting by certain user which is large enough etc. Comparing obtained results (even approximate) with the target pages, defined from web administrator's point of view, we can take into account the navigational behavior of users and to make decisions about problems in the web page linkage.

To gather information about most interesting pages for users at the chosen period, we need to analyze statistical data combined with hypertext structure's characteristics. This will allow studying page visits' flows and see navigation-related data.

For the analysis, we have constructed a mathematical model of hypertext structure and identified potential problems in it which may affect the reachability of the target pages. The easiest and most obvious option in this case is the application of graph model of the web site's hypertext structure. Investigations of graph models application possibilities have been researched by various authors; review of the results obtained is described in the work of Hollink, Someren and Wielinga [6].

In the most common way, the structure presented as a graph in which the vertices correspond to the pages of the site, and the edges are transitions from one page to another. Due to the one-pointedness of hyperlinks, we obtain a directed graph, as well as from one page may be several references to the other, then what we have oriented multi graph.

To combine graph methods with web statistics, we use the accumulated data as graph weights. Selecting different indicators (number of visits, visit duration, bounce rate), we normalize their values on a scale *[0..1]* and assign them to the verticals or edges. So we obtain a weighted graph model for the web site.

Then we set the lower threshold of weight *m*, from the range *[0..1]*, and choose from the source weighted graph only those elements which weights are larger than the selected value *m*. Thus, we obtain a partition of the initial graph (by selected indicator), which structure describes only the most important elements from user's point of view. The resulting set of pages may be evaluated as set of target pages defined by users' behavior. We can use this graph model to compare with target pages from our point of interest and see how these data correlate.

Also, it is possible to improve this algorithm by applying customization abilities for the threshold and by this manner regulate the number and "targetness" of most interesting pages for users.

We have applied the approach described above on the target pages for our (SSTU) website which are related to the admission campaign. First, we've selected a set of eight target pages, which contain major information about admission process, important dates, conditions and other related information. Then, we gathered data from Google Analytics about page views for chosen pages. Also we've taken into account only those page views which were performed from source page – the root of admission campaign's substructure. Number of page views has been normalized, and the threshold has been applied – the default threshold value has been set as the average of all target pages' visits number.

Table 2. Target pages' visits

#	Item Name	% of visits
1	Higher Education - Admission of 2013	47,5%
2	Schedule of Admission Committee	13,4%
3	Faculties and Departments	22,8%
4	List of Available Specialities	9,1%
5	New Specialities	3,3%
6	Accommodation and Hostel	2,4%
7	Affiliates	0,7%
8	Preliminary Courses	0,9%
--	**Threshold**	**12,5%**

To make it more obvious, we presented the results from Table 2 as the diagram.

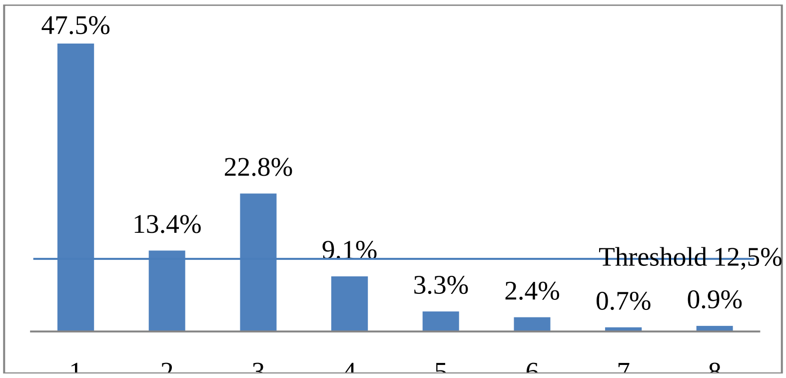

Figure 1. Target pages visits as a diagram

Results were surprising (see Figure 1): half of target pages were strongly under the threshold. It shows that web resource users have other imagination of target pages. Moreover, the additional target pages from users' point of view appeared. Refreshed results with new target pages highlighted are in the Table 3.

Table 3. Additional target pages' visits

#	Item Name	% of visits
1	Higher Education - Admission of 2013	38,8%
2	Faculties and Departments	18,6%
3	**About SSTU**	**12,7%**
4	Schedule of Admission Committee	10,9%
5	List of Available Specialities	7,4%
6	**Higher Education - Admission of 2012**	**5,5%**
7	New Specialities	2,7%
8	Accommodation and Hostel	1,9%
9	Preliminary Courses	0,8%
10	Affiliates	0,6%
--	**Threshold**	**10,0%**

The diagram on the Figure 2 shows results more explicitly.

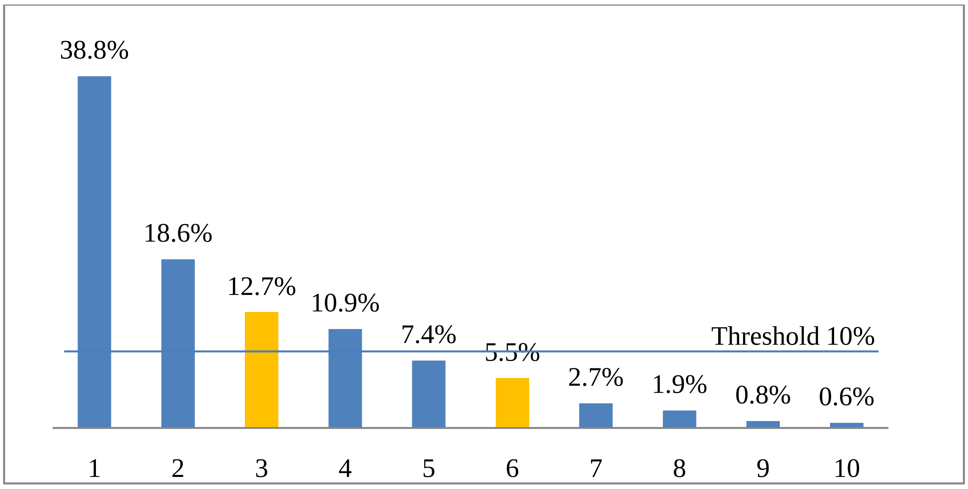

Figure 2 Additional target pages on the diagram

Such results stimulate to pay more attention for choosing target page process as well as to place important data on these pages.

4. Algorithm extension

If we return to web site's structure graph, we might update it according to the threshold applied to its edges' weights. Thus, pages with normalized weights under defined threshold would disappear, and only target ones would still persist.

Then, we will continue normalizing and applying thresholds for every persisted node one by one, while every persisted node would be processed. Finally, the web site's graph would be cleared from less visited pages, and we receive connected graph frame presented by most visited pages.
We have performed such approach briefly on the web site of institution, during admission campaign. Initial results let to assume that the structure of institution's web site has strong skeleton which in the majority has well-defined top visited pages. It is quite interesting, because such frame is corresponds well to the way the web site is maintained and fulfilled with data:

a) There is a major department which is responsible for the base web site's pages filling.
b) There are also minor groups, usually related to faculties and other departments, which are responsible for filling their substructures with department-specific data.

Thus, these substructures were disappeared after applying the approach and are not presented on the frame structure. Such disorder should be noted, the related problem should be solved on the administrative level. So anyway, the described approach gave the important results.

It is also important to point out, that the demonstrated approach was partly automated, by developing Java application with the algorithm implemented. Two major functions were also developed:

- Ability to parse requested web resource and to model its hypertext structure as the oriented graph;
- Ability to gather data from Google Analytics system as statistical data storage.

Such automation allows combining statistical data and information about navigational structure and explicitly shows these combined data. It is quite more useful than default graphical user interface of Google Analytics tool, which isn't adapted to solve such kind problems.

5. Conclusion

The analysis of web statistics opens wide capabilities to improve web resource development and administration. This paper demonstrates combining of different approaches, which were applied to educational institution's web site during admission campaign.

The first approach depicts how web resource's page visits may affect admission campaign and impact the number of enrollees' applications. Despite expected correlation between these numbers and number of page visits, results of the approach shown that some faculties may have abnormally high amount of page visits, and it should be noted by admission process managers.

The second approach extends web analytics' abilities by introducing mathematical methods of discrete mathematics. Gathered statistics may be combined with hypertext structure's data to discover new information about navigational behavior. The approach has been applied to define the set of target and top visited pages from users' point of interest. Then, the set has been compared with group of target pages, defined by web site administrator. Received results made to revisit the strategy of determining target pages and placing data on it.

Moreover, the second approach has been extended to determine whole web site's structure frame presented as oriented graph. It also pointed us on the possible problem of disorder between major frame (major substructure of the web site) and minor substructures, corresponding to the particular departments.

The demonstrated approach extends abilities of web analytics, as well as algorithm's automation and implementation as separated application extends abilities of Google Analytics tool. The developed application simplifies the process of web site analysis and allows performing it in more convenient and easy way. Functionality of the application may be extended to perform this analysis fully automatically and to support additional analyzing features.

The generalized results of the analysis of visits' statistics as long as analysis of the model of hypertext structure have formed the basis for next analysis. On this basis, recommendations were made for the re-engineering of hypertext structure to help users to find the information provided on the target pages, and to make more convenient working with the university's website for users.

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Collaboration and Service Innovation

Size and shape of the mobile applications development industry in the Western Cape, South Africa

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Abstract

This study explores the landscape for mobile applications development in the Western Cape, South Africa. A Gartner Special Report on "the mobile imperative" warns that "organizations need to deal with the uncertainty and speed of the consumer-driven mobile landscape". The proliferation of mobile technologies and "the increasing use of cloud back-end services", according to another Gartner report, is challenging IT sensibilities and should therefore be regarded as a disruptive technology. The mission and mandate of the Cape Peninsula University of Technology (CPUT) emphasise its leadership role in human resources and service provision to the community and industry around the academic disciplines of the university. The university is particularly keen on developing its role with respect to technology skills development and transfer towards community development and the energising local industry. It is specifically with regard to the latter that this study was undertaken. In order to be of service to the local mobile applications development industry, the university needs to have a clear sense of its size and shape. The study seeks to profile the local mobile applications development industry in terms of – (a) focus and functionality of applications delivered, (b) profile of clients, (c) development platform, e.g. iOS, Android, Windows, Java, etc., (d) in-house expertise and special skills, and (e) scarce skills needs. It is instructive to note that on the websites of the Indeed online recruitment agency, that there were 1200 vacancies for "mobile application developer jobs" on their "dot za" site and 14000 vacancies on their "dot com" site (on 14 July 2013). It is important for CPUT to understand the size and shape of the mobile applications development industry in its local region in order for it to fulfil its mission and mandate as a university of technology. Knowledge about the human resource needs of industry would inform curriculum design and student enrolment for academic programmes. These programmes could conceivably be either formal for qualifications or non-formal for "right skilling". Knowledge about the technology needs of industry could inform the research and development (R&D) activities of the university. The university and the industry could partner in seeking appropriate solutions for technology challenges that might present. Knowledge about the nature of "disruptive technologies" would inform the business modelling and strategic management of the partner organisations. Finally, knowledge about the size and shape of the mobile applications development industry in the Western Cape, South Africa, could serve as a baseline study for future status and trend analysis. Extensive use will be made of Gartner resources to establish the parametric framework of analysis for this study. Scholarly articles elucidating the notion of "disruptive technology" will also be accessed. This is an exploratory study. The research framework will be benchmarked against Gartner approaches for "size and shape" research. This will allow for comparative analysis at a later stage. Data collection on the status of the local industry will be conducted using a structured survey instrument which will be administered using the dual mediums of personal and telephone engagement. This study provides a basic survey report on the size and shape of the mobile applications development industry of the Western Cape, South Africa.

Keywords: *Disruptive technologies, Mobile applications development.*

1. Introduction

This research project which forms part of a larger study explores the landscape for Mobile Applications (apps) Development in the Western Cape, South Africa. A Gartner Special Report on "the mobile imperative" warns that "organizations need to deal with the uncertainty and speed of the consumer-driven mobile landscape". The proliferation of mobile technologies and "the increasing use of cloud back-end services", according to another Gartner report, are challenging Information Technology (IT) sensibilities and should therefore be regarded as a disruptive technology [1].

The mission and mandate of the Cape Peninsula University of Technology (CPUT) emphasise its leadership role in human resources and service provision to the community and industry around the academic disciplines of the university. The university is particularly keen on developing its role with respect to technology skills development and transfer towards community development and the energising local industry. It is instructive to note that on the websites of the "Indeed" online recruitment agency, that there were 1203 vacancies for "mobile application developer jobs" on their "dot za" site and 14121 vacancies on their "dot com" site [2].

It is important for CPUT to understand the size and shape of the mobile applications development industry in its local region in order for it to fulfil its mission and mandate as a university of technology. Knowledge about the human resource needs of industry would inform curriculum design and student enrolment for academic programmes. These programmes could conceivably be either formal for qualifications or non-formal for "right skilling". Knowledge about the technology needs of industry could inform the research and development (R&D) activities of the university. The university and the industry could partner in seeking appropriate solutions for technology challenges that might present. Knowledge about the nature of "disruptive technologies" would inform the business modelling and strategic management of the partner organisations. Finally, knowledge about the size and shape of the mobile applications development industry in the Western Cape, South Africa, could serve as a baseline study for future status and trend analysis.

2. Literature Review

2.1. The history of mobile applications

The mobile phone has become the most popular form of electronic communication for many people [3]. Nearly a decade later, Clark [4] supports this view by suggesting that mobile communication has become such an integral part of people's lives that many feel peculiar without a mobile phone. In the earliest forms, the most popular functions of mobile phones were calling and sending text messages. These functions were extended with the advent of the smart phone which is a multifunctional mobile device that not only communicates via voice and text, but also affords the user to research, work and have fun via the development of mobile applications. At the end of the twentieth century, mobile applications were typically small arcade games (like Tetris in 1994 [5], then Snake in 1997 [6]), ring tone editors, calculators, calendars, etc.

Early phones had very small monochrome low-resolution screens and limited storage and processing power. The phones could not handle the data-intensive operations required by traditional Web browsers. The bandwidth requirements for data transmission were also costly to the user.

The Wireless Application Protocol (WAP) standard was developed in 1997 to address the concerns that mobile phones could not handle the data-intensive operations required by traditional Web browsers. WAP was a stripped-down version of HTTP, which is the basic protocol of the World Wide Web. WAP browsers were designed to run within the memory and bandwidth constraints of the phone. Third-party WAP sites served up pages written in a markup language called Wireless Markup Language (WML) as opposed to Hyper Text Markup Language (HTML) and the pages were much simpler in design than the WWW pages.

The frivolity of the mobile applications changed significantly at the turn of the millennium when manufacturers tried to make their products more attractive for customers by introducing increasing amounts of applications. The BlackBerry 5810 released in 2002 was the first true BlackBerry device [7]. The mobile phone with integrated email functionality, calendar functions and a selection of primitive apps, was preferred by business users. The Treo 650 smart phone by Palm was a hybrid Personal Digital Assistant and cellphone that was introduced late in 2004 and eventually discontinued in 2008 [8]. The technology included increased memory, more interactive apps, a built in camera as well as touch screen capability which spelt a definite sign of things to come in mobile phone technology. The IPhone 5 by Apple, is regarded as one of the most impactful electronic devices in history. Its designer, Steve Jobs has not only impacted the technological community but the device is a cultural gem in the United States and worldwide. The smart phone is more powerful than the computer on the Apollo 11 space craft of 1969. The App Store has the world's largest collection of mobile apps in 2013[9].

2.2. The dynamic mobile landscape

Leading IT companies like Gartner, Forrester and Juniper along with the ITU (International Telecommunication Union) who is the United Nations specialized agency for information and communication technologies reveal promising findings for mobile application development in the next few years.

Much of the enterprise application development takes place outside the scope of IT in the form of business unit application development, end-user application development and development outsourced by business units to third parties. Historically, most mobile application development not performed by IT has been outsourced. This is beginning to change with the emergence of visual application (app) builders and other forms of rapid mobile application development tools. With the increased demand for mobile applications, non-IT developers will increasingly look for ways to provide mobile applications that satisfy their business requirements, and they will begin building their own mobile applications [1].

Innovation in the world of mobile apps is increasing dramatically with an expected market of $38 billion by 2015. Despite the thousands of apps already having been developed, business opportunities associated with apps are just at infancy stage. From one end of the spectrum with personalized, local and social apps right through to the enterprise market which alone is well on the way to spending $17 billion deploying apps, the overall market and number of use-cases are escalating exponentially. All of this is fuelled by modern smart phones [10].

By 2017 over 160 billion apps will be downloaded globally onto consumer handsets and tablets. This sharp increase, from 80 billion in 2013, is a result of many consumers in developing markets upgrading from feature phones to smart phones, and a growing number of apps downloaded at no upfront cost to the user [11].

There are 5.9 billion or 87% of the world's population that are mobile subscribers. Of this China and India have nearly 1.8 billion subscriptions. The Global mobile statistics 2012 report states that mobile devices sales rose in 2011, with smart phones showing the resilient growth but feature phones are still selling intensely. Nokia remains the number one handset manufacturer, but Samsung is now the leading smart phone hardware vendor with the top smart phone operating system being Android. There are 1.2 billion mobile Web users worldwide, with the highest usage in Asia, particularly in South Korea and Japan who lead in mobile broadband penetration with 91 and 88 percent respectively. Mobile devices account for 8.49 percent of global Website hits. In the US, 25 percent of mobile Web users are mobile-only, i.e. they do not, or very rarely use a desktop, laptop or tablet to access the Web. Japanese mobile users are still more progressive in mobile behaviour, using mobile Web, apps and email more, but US and European users prefer to text (up to 8 trillion text messages worldwide in 2011) and play more games on their mobiles. Most popular mobile destinations are news and information, weather reports, social networking, search and maps [12].

In the subsequent report by the International Telecommunication Union [12] there appears to have been continued and almost universal growth in ICT uptake. Much of this enhanced connectivity is as a result of

40% rise in 2011 of mobile-broadband subscriptions, to the point where there are now twice as many mobile-broadband as fixed-broadband subscriptions. The surge in numbers of mobile-broadband subscriptions in developing countries has brought the Internet to a multitude of new users [13].

2.3. The Different Types of Mobile Applications

Table 1: Mobile Applications can typically be categorised as follows [14, 15]:

Category	Description and example
Calculate / Utilities	These apps are able to do calculations like mortgage payments, convert temperatures, etc.
Games Apps	These mobile gaming apps are entertaining and very popular.
News Apps	Users can get the news delivered to their smart phone in real time.
Productivity Apps	Users can be more productive by using their smart phone to scan and send documents, etc.
Search Tool Apps	These apps allow users to find information by using their smart phone.
Social Networking Apps	These apps include apps such as Facebook, Twitter, Pinterest, etc
Sports Apps	These apps are useful for those who want all the latest sports news.
Travel Apps	These apps are useful for those who are travelling.
Weather Apps	These apps allow users to receive their daily weather forecast to a smart phone.

2.4. Mobile Applications: a case of disruptive technology

A disruptive technology is, “One that causes major change in ‘the accepted way of doing things’, including business models, processes, revenue streams, industry dynamics and consumer behaviour.” There has been significant acceleration in the development of disruptive technologies like Mobile Computing and Cloud Computing in recent years [16]. Christensen [17] extends this definition by stating that disruptive technology is a new technology that unpredictably dislodges established technology. The author distinguishes between sustaining and disruptive technologies. Sustaining technologies depend on gradual improvements to entrenched technology. Disruptive technologies are unsophisticated, lack performance because of their novelty, appeal to a narrow audience, and may not yet have a tested practical application. An example of this would be Alexander Graham Bell's invention of the "electrical speech machine" in 1874, while he was toying with an earlier idea, the "harmonic telegraph" that could send more than one telegraphed messages at once. These are the pioneering technologies to not only the telephone but also modern smart phones and tablet computers.

Even though Christensen [17] predates many modern disruptive technologies, the author’s argument is still true today. “Large corporations are designed to work with sustaining technologies. They excel at knowing their market, staying close to their customers, and having a mechanism in place to develop existing technology. Conversely, they have trouble capitalizing on the potential efficiencies, cost-savings, or new marketing opportunities created by low-margin disruptive technologies.”

Schadler [18] reinforces the Gartner view [16] by suggesting that businesses can improve efficiencies to their customers, partners, and employees with systems of engagement brought about by mobile, social, big data, and cloud technologies. Systems of engagement refer to the capability to empower all the business stakeholders with context-rich applications and smart products to assist them to make decisions and to take immediate actions at the appropriate time and place.

“These new systems harness a perfect storm of mobile, social, cloud, and big data innovation to deliver applications and smart products directly in the context of the daily lives and real-time workflows of customers, partners and employees. The compelling notion of context is the sum total of what your customer has told you and is experiencing at the moment of engagement is made possible with cloud delivery and predictive analytics applied to a blend of data from device sensors, social feeds, personal preferences, and systems of record” [18].

Tynan [19] supports Christensen [17] with the argument that IT is extremely dynamic and its development certainly has a means of grasping established ideas and engrained industries and turning them on their head. Information technologies will often pair up to become disruptive technologies. An example of significant partnering disruptive technologies is how digital video has encouraged mass movie production. Social media applications afford the masses an opportunity to stage their amateur movies which is having a significant impact on sectors like journalism, politics, and entertainment. Certain technological devices have been impacted by disruptive technologies. What was once indispensable devices are now being replaced by smarter and ostentatious ones. An example of this is how external Global Positioning System navigation devices are being threatened by smart phones largely on account of the Android operating system that extends Google Maps to phones and tablets.

3. Research Methodology

This explorative research project consisted of a literature analysis, a focused interview [20] with academics and students of the Department of IT at CPUT, as well as a survey of a stratified random sample of small Mobile Application Development and Software Development businesses in and around Cape Town. The aim of these methods was to obtain the status of the local industry by using a structured survey instrument which was administered using the dual mediums of personal and telephone engagement. The constraint on the sample size of the study was the availability of these businesses to be interviewed. The findings of the study were interpreted from a qualitative rather than a quantitative perspective due to the relatively small sample size of the respondents, where the validity and reliability of the data could be questioned.

Emerald, EBSCOhost and Google Scholar were the preferred means of searching for accredited journal articles, conference papers, white papers, associated business journals and other academic sources in order to produce a comprehensive overview of Cloud Computing, Mobile Computing, Disruptive Technologies and Mobile Application Development.

The available literature on the field of study is vast and as a result it was not realistic to make a comprehensive study of all previous knowledge of the relevant research themes. Instead, the focus was on searching and selecting high-impact references, with distinguishing accent on research providing concrete empirical evidence particularly when it applied to usage and adoption statistics. Information technology professionals' insights posted on reputable websites and blogs as well as in business magazines were also deliberated. The purpose of linking the professional with the academic viewpoints was to reap more considerations from diverse sources as well as current statistics, to augment the research project.

A total number of seven Mobile Application Development and Software Development businesses were surveyed in and around Cape Town. The business representatives interviewed were 4 Managing Directors, 1 Founder, 1 Technical Adviser and 1 Senior Applications Developer.

3.1. Business involved in Mobile Application Development

Four of the seven of the businesses have already been involved with Mobile Application Development projects before. Those businesses who were involved with Mobile Application Development have been doing so for between 2 and 5½ years. Their largest budgets ranged between R200,000 and R700,000 and their number of completed Mobile Application Development projects were as low as 2 and the highest been 22.

Three of these businesses developed their apps specifically for clients and with the intention to generate revenue from them. The majority of their clientele were commercial entities and one business had mobile phone users between 12 and 40 years of age as clients. Commercial entities were prepared to pay between R40,000 and R80,000 for Search Tool Apps, Sport Apps and Travel Apps. Productivity Apps and Calculate/Utilities Apps are more costly and ranged between R100,000 and R1,000,000 depending on their functionality. Two of these businesses were unable to generate income from their apps after having successfully completing them.

All of the businesses designed cross-platform apps and believed that it did not make business sense to design platform specific apps as it restricted the commercial viability if it were designed specifically for

Android, IOS or Blackberry. Table 2 lists the technologies and skills that these businesses suggest which are required for Mobile Applications Development:

Table 2: Skills and technologies required for Mobile Applications Development

Technologies used in app development	Skills (Less Scarce)	Skills (More Scarce)
CSS	CSS	Database Language - Oracle Apex
HTML5	Design	Jquery Mobile
Java	HTML5	Phonegap
Jquery Mobile	Javascript	
Oracle Apex 4.2	Jquery	
Phonegap	PHP Cake Framework	
PHP	Web Services	
Xamarin	General Mobile Application Development	

The majority of these businesses outsource one or other function of their Mobile Applications Development project to other entities. Typical outsourced functions include design of the app. Trends in Mobile Application Development include:

- Perfect synchronisation between desktop and mobile
- More cloud services via mobile phones
- Increase in Productivity Apps

The majority of the businesses believed that a model which could provide a strategy for enhanced commercialization of Mobile Applications Development would assist them in Mobile Application Development. The model should assist them with the commercialisation of the app once it had been completed. Commercialisation is a major challenge. The business who marketed their app to the open market, suggested that the best commercialisation option would be to go via a service provider (like Vodacom, MTN, Cell C, etc.) so that users could pay for the app via air-time charges rather than a credit card transaction as many would not necessarily have access to a credit card.

All of the businesses collaborate with at least one other company when developing Mobile Applications for at least one of the following purposes:

- For mobile payment gateways
- Mobile marketing
- Design of the User Interface and User Experience
- Technical skills when they cannot meet the technical requirements of the app

3.2. Business not involved in Mobile Application Development

The majority of those businesses, who were as yet not involved in Mobile Application Development, intended to so imminently. Reasons why these businesses were not involved as yet but would consider getting involved with Mobile Application Development are listed in table 3.

Table 3: Reasons for either being or not being involved in Mobile Applications Development

Reasons why not involved	Reasons why to be involved
"It has not been the company focus up to now"	"Our customers are asking for it."
"We don't have the necessary skills"	"We believe that a mobile device without a mobile app is useless."
"We would need assistance to get us started."	"We believe in fostering a mobile application development culture to tap into the business potential of it."
"We are an SMME. We don't have the necessary skill and staff to do so."	"We believe that the future is mobile. It is a niche area."
"We believe that there are already many players in the space and it is problematic generating an income from the app."	"Our clients typically want a .mobi site as well as a mobile app for their present business."
	"We believe that there is money to be made."
	"There seems to be opportunity in Mobile Application Development"

Of the businesses who believed that a model which could provide a strategy for enhanced commercialization of Mobile Applications Development, suggested that it should assist them with the following:

- "Give us guidelines as to how to approach this mobile application opportunity."
- "Tell us where to start."
- "It should tell us what skills and technologies are needed."
- "Tell us what the trends are."
- "What phases are involved in the mobile applications development?"
- "What architecture should be used?"
- "Describe the security considerations since this involves cloud computing."
- "Tell us about design concerns."
- "Inform us about the user interface and user experience."
- "Help us to plug the gap between the end product and revenue generation."

All of the businesses acknowledge that they would have to make some adjustment to their current business models but that it would not have to be drastic changes. Appointment of key staff appears to be the biggest adjustment to their current business.

These businesses regard the following categories of Mobile Applications as being most popular and those that they would consider developing in the near future:

Table 4: Popular apps and those that would be considered for development in the near future

Most popular apps	Apps to be developed in the near future
Calculate/Utilities Apps	Calculate/Utilities Apps
Games Apps	Productivity Apps
News Apps	Social Networking Apps
Productivity Apps	
Social Networking Apps	
Weather Apps	

The majority of the businesses were unsure of what category of applications they should develop in the near future and indicated that the strategy model should inform them.

All of the businesses believed that it did not make business sense to design platform specific apps as it restricted the commercial viability if it were designed specifically for Android, IOS, Blackberry, etc and that it should be designed cross-platform. Their client base would be their present customers from the corporate and SMME sector and not "the man in the street". Most of these businesses will charge their business clients for the app and they believe that the client would pay as much as R100,000. The rest of the businesses will not charge for their apps as they believe that people want free apps. They will however charge for the services generated from the app and will focus on winning new clients in this regarding the app as a marketing tool.

All the businesses stated that they did not have the permanent and necessary skills for Mobile Application Development projects and that they would have to either outsource this function or make contract appointments in order to do so. They would obtain the skills from universities via the internship programmes or make use of web portals such as Gumtree where the relevant skills are advertised for employment.

As a means of marketing their apps, the businesses would make use of their normal marketing channels like their website, email and public relation campaigns to sell a solution and not an app in itself. One business indicated that they would make use of Google Play, App Store, etc.

3.3. Mobile Application Development at Cape Peninsula University of Technology

In a focused interview with key stakeholders (including students and academics) in the Department of Information Technology at Cape Peninsula University of Technology (CPUT) it was agreed that Mobile Application Development is not offered in the formal curriculum but rather at the co-curricular level, within a unit referred to as the Kujali Hub. The Kujali Hub harnesses human and research capacity to develop innovative ideas especially in mobile technologies. Presently, students are exposed to some of the technologies relating to Mobile Application Development in subjects like Development Software and Technical Programming but students do not design a complete Mobile Application project.

A comparative study of the websites of the “Indeed” online recruitment agency over a period of 17 days revealed a significant increase in the number of vacancies for “mobile application developer jobs” on their “dot za” site and on their “dot com” site.

Table 5: Comparison of the number of Mobile Application Development job advertisements

	14 July 2013	31 July 2013	% Variance
http://www.indeed.co.za	1 203	1 527	+27
http://www.indeed.com	14 121	25 162	+78

4. Discussion

Four of the seven software development businesses surveyed in and around Cape Town were already involved in Mobile Application Development and only one of the businesses are not doing so imminently. The majority of the seven businesses acknowledged the business potential of Mobile Application Development and half of them have generated income from their previous Mobile Application Development projects.

All of the businesses, excepting one expressed the importance for a model which could provide a strategy for enhanced commercialization of Mobile Applications Development. Those who are involved with Mobile Applications Development require the model to assist them with revenue generation once the app has been completed. Those businesses who are not involved with Mobile Application Development needs are far more intense and involve the full spectrum from the initiation through to commercialisation of the app. These businesses have expressed the importance of them being unable to take risks without a model that could help them to minimise these risks by providing them with clear guidelines, trends, technologies, skills, marketing, etc relating to Mobile Applications.

The participants in the focused interview acknowledged that Mobile Application Development should be offered in the formal curriculum at undergraduate level on the National Diploma of Information Technology. The students recommended that the learning must result in a complete Mobile Application Development project at the end of their third year of studies. They also proposed that they be taught design as a subject which would assist them with the designing of Mobile Applications Development. They believed that interaction with CPUT Design Department students could assist them, as they do not have the natural creative flair that the design students have. The introduction of the new National Diploma of Information Technology which is to be implemented in 2015 at CPUT, will allow for this opportunity.

5. Conclusion

The study is consistent with [1] regarding the fact that the proliferation of mobile technologies is challenging IT sensibilities and should therefore be regarded as a disruptive technology. There is a significant need for Mobile Application Development jobs as indicated by “Indeed”, an online recruitment agency. If CPUT wishes to remain responsive to the needs of industry, it should consider formalising Mobile Application Development into the formal curriculum rather than simply offering it as a co-curricular activity.

The software development businesses have acknowledged the potential in Mobile Applications but appear to have difficulty in commercialising these apps. Further research is warranted around the establishment of a model which could provide a strategy for enhanced commercialization of Mobile Applications Development that would assist businesses in Mobile Application Development. This model would have to address a number of concerns, depending on the propensity of the business towards Mobile Application Development. Research into what adjustments to the current business models of these businesses are required to enter into Mobile Application Development is also recommended.

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Presenter: The paper is presented by Errol Francke

Launching the South African Department of Energy's Energy Efficiency Target Monitoring System

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Abstract

The South African Department of Energy (DoE) developed the 2005 National Energy Efficiency Strategy (NEES) setting sectoral targets, in the industrial and mining, residential, transport, commercial and public buildings, for energy efficiency improvement by 2015. The 2005 NEES has been under review regarding the process and monitoring of the sectoral targets that were set up to 2015. The overall target was defined as 12% in the national energy demand by 2015. In order to support the implementation of energy efficiency interventions in South Africa, the Swiss Agency for Development and Cooperation (SDC) supports the Department of Energy by means of the launching and operationalization of an energy efficiency target monitoring system (EETMS) for energy efficiency in the Industrial, Commercial and Public Buildings, as well as the Residential Sector. The programme is committed to supporting the reduction of energy demand and carbon emissions in South Africa and analysing energy efficiency trends. The aim of the EETMS is to determine whether South Africa is on track in achieving the Energy Efficiency targets that were set for the improvement of energy efficiency in all sectors, including buildings. The EETMS project is funded by the Swiss Agency for Development and Cooperation (SDC) and implemented by the South African Department of Energy (DoE).

Keywords: *Energy Efficiency Strategy, Energy efficiency target monitoring system, Energy efficiency trends*

1. Introduction

The National Energy Efficiency Strategy (NEES) for South Africa, March 2005 (Reviewed October 2008) is published in the 22 May 2009 Government Gazette No.32249. It is gazetted that the South African Department of Energy (DoE) developed and set the 2005 NEES targets, in the industrial and mining, residential, transport, commercial and public buildings, sectors for energy efficiency improvement by 2015. The two authors are in the process of developing the Swiss Agency for Development and Cooperation (SDC) funded Energy Efficiency Target Monitoring System (EETMS) to determine whether South Africa is on track to meet the overall 12% energy efficiency target by 2015. The "25 Energy Efficiency Policy Recommendations - 2011 Update" which recommended that G8 leaders be dedicated in adopting and urgently implementing measures that would significantly enhance energy efficiency in their respective countries, according to the German 2007 International Energy Agency Energy Policy Review, underpinned Germany's energy efficiency policy [1], [2]. On 11 November 2005, Germany laid down the following targets for national energy efficiency according to their Energy Efficiency Action Plan:

- Increase the energy efficiency of the national economy with the objective of doubling energy productivity (a measure of GDP output per unit of energy use) by the year 2020 compared to 1990, requiring an annual increase of 3%,

- Increase funding for the CO_2 Building Rehabilitation Programme to at least *EUR 1.5 billion* per year; improve the efficiency and attractiveness of the programme (for example by switching to investment grants and tax relief measures and by including rental accommodation), and,
- Introduce an energy passport for buildings, with a target of improving energy efficiency in 5% of pre-1978 buildings every year [2].

Figure 1 indicates how some of the Western European countries improved their energy intensity (see section 1.1 below) levels from 1973 to 2010 [2]. Likewise, South Africa is committed to fostering energy efficiency in all energy sectors on a national scale.

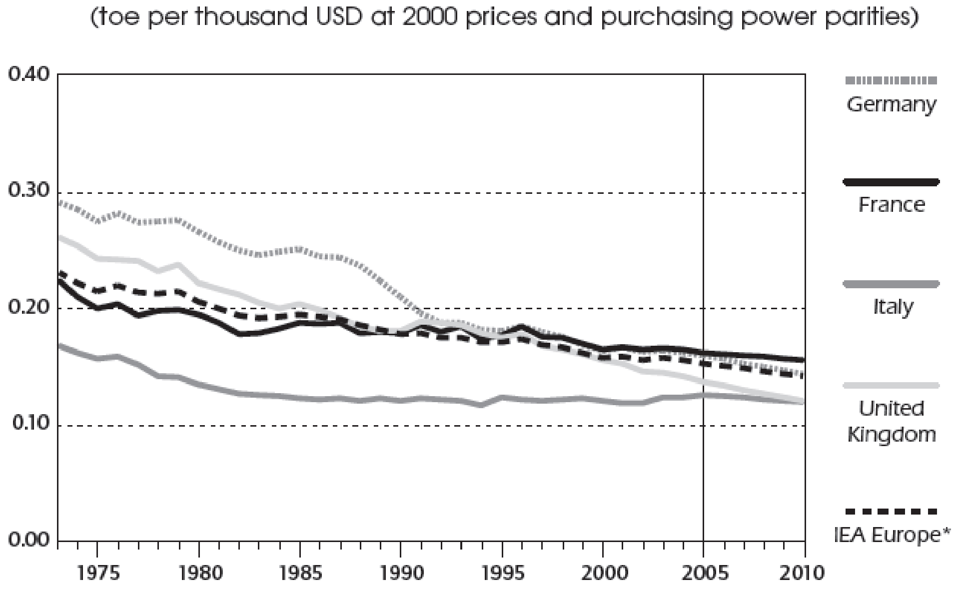

Figure 1. IEA countries Energy Intensity trend [2]

According to Liu, Meyer and Hogan, building energy efficiency codes (BEECs), with energy efficiency standards are regarded as necessary government interventions. This is to overcome persistent market barriers to capturing the economic potential of energy efficiency gains in the residential, commercial, and public service sectors. Implementation of BEECs helps prevent costly energy wastes over the lifecycles of buildings and energy systems in space, air conditioning, lighting, and other energy services. However, the full potential of energy savings requires people who occupy these to be held accountable for the cost of energy services. Mandatory energy efficient design requirements for buildings were first introduced in Europe and North America in the late 1970s. This has proven to be an effective policy instrument. Compliance enforcement has been the biggest challenge to implementing BEECs. This is challenging because of variations in local government political and resource support, robustness of the enforcement infrastructure, and conditions of the local construction market. These compliance enforcements of building energy efficiency codes in developing countries are in the main non-existent [3]. One of the key components of the Swiss Agency for Development and Cooperation supported programme is the institutionalisation of an energy efficiency monitoring system within the South African government. The detailed data sets required as input to the monitoring system will be obtained from the various energy sectors.

1.1. Energy efficiency and energy intensity

Energy efficiency is defined as the ratio between the useful output of an energy conversion system and its input, in energy terms or $\eta = \frac{Pout}{Pin}$.

With: η : efficiency
P_{out} : total output power
P_{in} : total input power

The useful output varies from electric power, mechanical work, or heat, etc. Another way of expressing energy efficiency is as the ratio between energy consumption and economic output or energy intensity. However, to determine energy efficiency trends it is not as straightforward and the following formulae [6] are displayed below to prove the point.

If E is the total energy consumption in an industry and Y is the total industrial production in a country. Let us assume there are n industrial sectors, and E_k and Y_k are the energy consumption and production level in the k^{th} sector, respectively. For sector k let us define the sectoral energy intensity $I_k = E_k/Y_k$ and the industrial production share $S_k = Y_k/Y$. The aggregate energy intensity $I = E/Y$ can be reformulated as shown in Equations (1) – (4):

$$I = \sum_{k=1}^{n} \left(\frac{E_k}{Y_k}\right) * \left(\frac{Y_k}{Y}\right) = \sum_{k=1}^{n} I_k S_k \tag{1}$$

$$\begin{aligned}
I_t - I_{t-1} &= \sum_{k=1}^{n} S_{k,t} * (I_{k,t} - I_{k,t-1}) + \sum_{k=1}^{n} I_{k,t} * (S_{k,t} - S_{k,t-1}). \\
I_{t-1} - I_{t-2} &= \sum_{k=1}^{n} S_{k,t-1} * (I_{k,t-1} - I_{k,t-2}) + \sum_{k=1}^{n} I_{k,t-1} * (S_{k,t-1} - S_{k,t-2}). \\
&\ldots\ldots \\
I_1 - I_0 &= \sum_{k=1}^{n} S_{k,1} * (I_{k,1} - I_{k,0}) + \sum_{k=1}^{n} I_{k,1} * (S_{k,1} - S_{k,0}).
\end{aligned} \tag{2}$$

Equation (2) leads to:

$$I_t - I_0 = \sum_{j=1}^{t} \sum_{k=1}^{n} S_{k,j} * \left(I_{k,j} - I_{k,j-1}\right) + \sum_{j=1}^{t} \sum_{k=1}^{n} I_{k,j} * \left(S_{k,j} - S_{k,j-1}\right) \tag{3}$$

$$EF_t \left(\text{or} \frac{E_t}{Y_t}\right) = \sum_i \frac{E_{it}}{Y_{it}} * \frac{Y_{it}}{Y_t} = \sum_i I_{it} S_{it} \tag{4}$$

With:
E_t: total industrial & agriculture energy consumption in year t
E_{it}: energy consumption in sector i in year t
Y_t: total Industrial & agriculture economic output in year t
Y_{it}: economic output of sector i in year t
S_{it}: output share of sector i in year t (Y_{it}/Y_t)
I_{it}: energy intensity of sector i in year t (E_{ti}/Y_{it})
EF_t: energy efficiency in year t (E_t/Y_t)

The World Energy Council defined energy efficiency as follows: "Energy efficiency improvements refer to a reduction in the energy used for a given service (heating, lighting, etc.) or level of activity. The reduction in the energy consumption is usually associated with technological changes, but not always since it can also result from better organisation and management or improved economic conditions in the sector (non-technical factors)" [4].

In the main, energy is measured in its final useful form to the end user, whether the fuel is in its primary or secondary form. The primary form is when the fuel is still in its natural resource. Secondary forms are transformed energy outcomes such as electricity or by the products of coal, oil, uranium or sunlight, etc. In the process of converting primary energy into secondary forms of more worthwhile energy products, it results in substantial energy losses. According to the IEA, approximately one third of the energy is wasted worldwide in secondary energy production [5]. This is evident in electricity generation, petroleum production, gas liquefaction or regasification processes. Consuming one Tera Joule (TJ) of electricity is not equivalent to consuming one Tera Joule of natural gas or coal due to the upstream losses in the production of the electricity. Primary energy input per unit of electricity is between one to three times the final energy value according to some methodologies [7]. When comparing energy use between different entities, energy consumption needs to be calculated in primary terms by adjusting the final energy consumption and accounting for losses. These losses materialise in the generation, transmission, and distribution of the energy. Results are to be provided in terms of both final and primary energy and to clearly indicate the accounting methodology. The Direct equivalent method (SRES method), Physical energy content method (IEA method) and the Substitution energy method are some of the methodologies that can be used in determining Energy Efficiency. Subsequent to the development of the energy efficiency monitoring system, the Department of Energy also developed reporting procedures including questionnaires to collect energy data from the public building sector. This data is used, with the assistance of a custom-developed software package, to determine the energy efficient levels in each of the surveyed sectors, viz. residential, commercial, industrial and transport.

2. Methodology

The South African National Energy Efficiency Strategy (NEES) (2005) clearly defines the sectors and their respective energy reduction targets that are considered a priority for the South African Government's 2010 – 2015 Energy Efficient Building Programme. The aspirational targets are as follows;

- Industrial and mining (*15%*),
- Commercial (*15%*),
- Public buildings (*15%*),
- Residential (*10%*), and,
- Transport (*9%*).

A crude preliminary analysis is possible using existing data sources, but the results do not provide an accurate indication of efficiency changes due to the insufficient process detail within the data sets. The aim of the EETMS pilot phase was to work with key data providers to identify the data sets necessary to provide an accurate indication of efficiency changes for the programme. The launch of the EETMS with project implementation began in January 2012. The Energy Efficiency Target Monitoring System uses 'decomposition' analysis to attribute changes in final energy consumption according to different causes, such as:

- Activity level changes
- Structural changes
- Efficiency changes

By making use of energy consumption equations similar to Equations (1)–(4), the derivation of the abovementioned changes are displayed in the flowchart in Figure 2 in the decomposition analysis [8].

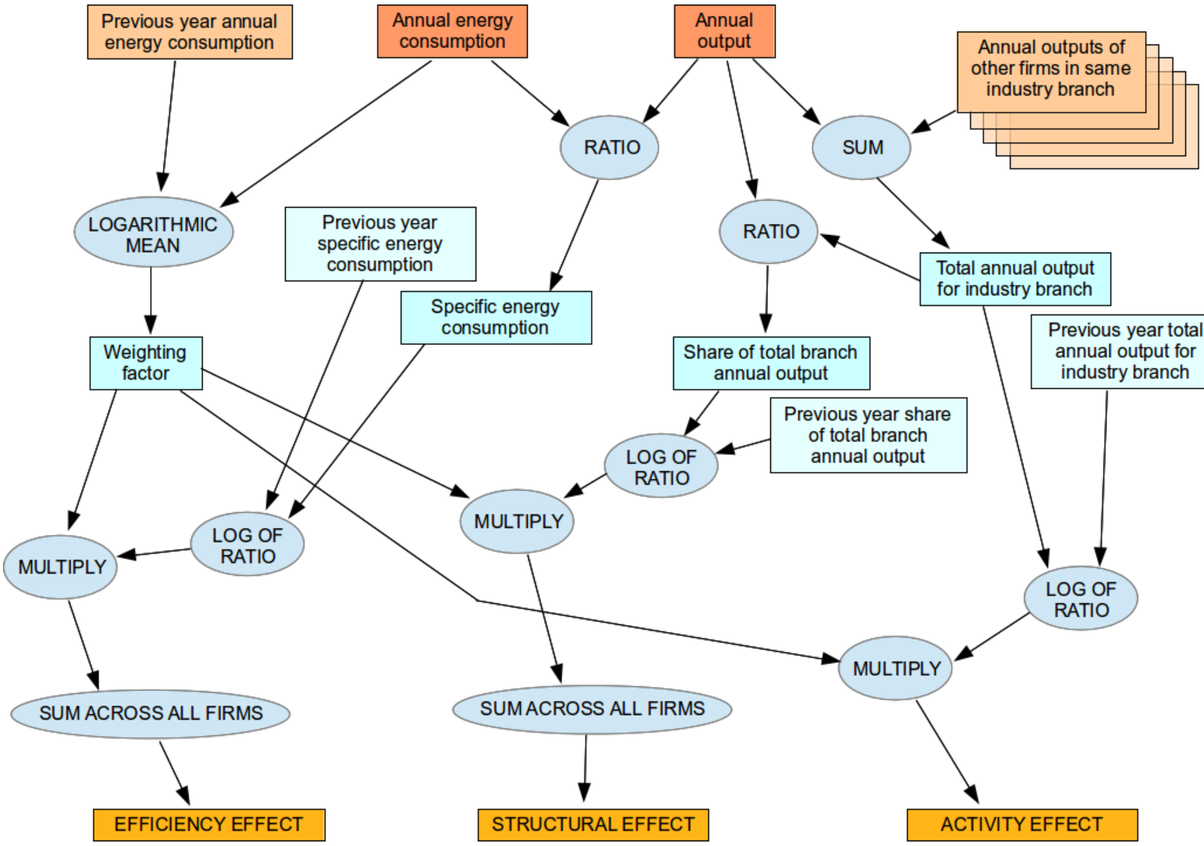

Figure 2. Flowchart of decomposition analysis [8]

The Energy Efficiency Target Monitoring System is a work in progress, and the pilot phase was launched up to March 2013, and is currently followed by a two year roll-out phase. A broad framework of the design is fixed and the decomposition approach is well established internationally. The pilot phase was an opportunity for the Department of Energy to:

- Develop a detailed system design based on stakeholder comments and recommendations, and
- Work with key data providers to establish data flows.

The goal was to establish a functional context appropriate system for the purposes of routine monitoring of energy efficiency through energy data gathering. The pilot will provide a clear indication of the progress being made towards achieving the energy efficiency targets set out in the Energy Efficiency Strategy. It will also provide a reporting system that will enable monitoring of progress in the achievement of the energy efficiency targets.

3. Results

The methodology is top down as opposed to bottom up, using a decomposition approach. Changes in total energy consumption are analysed and the effect of structure, activity and efficiency are identified. The sectors that are currently covered and analysed are: Industrial, Commercial, Public and Residential. The Transport sector is to be included in 2014. The pilot phase results of the EETMS project proved that the methodology is functional. In the up-scaling phase of the project the cumulative change in energy consumption will also be shown in the form of a graph displaying Total Energy Change, Activity Effects, Structural Effects and Efficiency Effects as illustrated in the example in Figure 3.

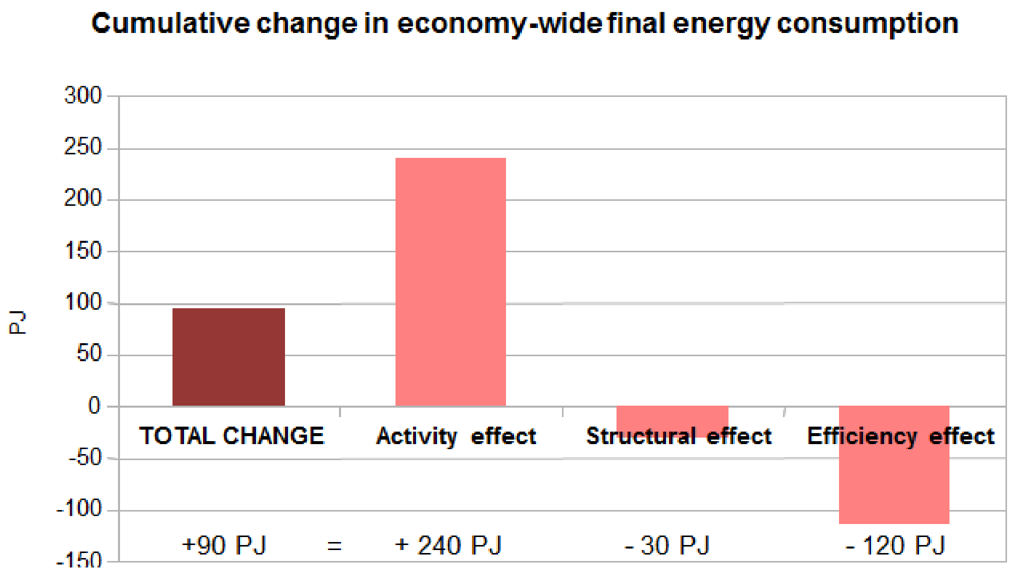

Figure 3. Cumulative change in energy consumption

The value of energy intensity shows how many units of energy (say TJ) are consumed for the production of 1 unit of economic output (say millions of Rands). If we now look at Figure 4 of the South African aggregate energy intensity against energy consumption/GDP of Inglesi-Lotz and Pouris, the total economy decreased its energy demand to produce *R1 million* from *1.165 TJ* in 1993 to *0.787 TJ* in 2006. In other words, the required energy to produce R1 million decreased by *32.44%* from 1993 to 2006, with an average year on year decrease of *2.83%* [6].

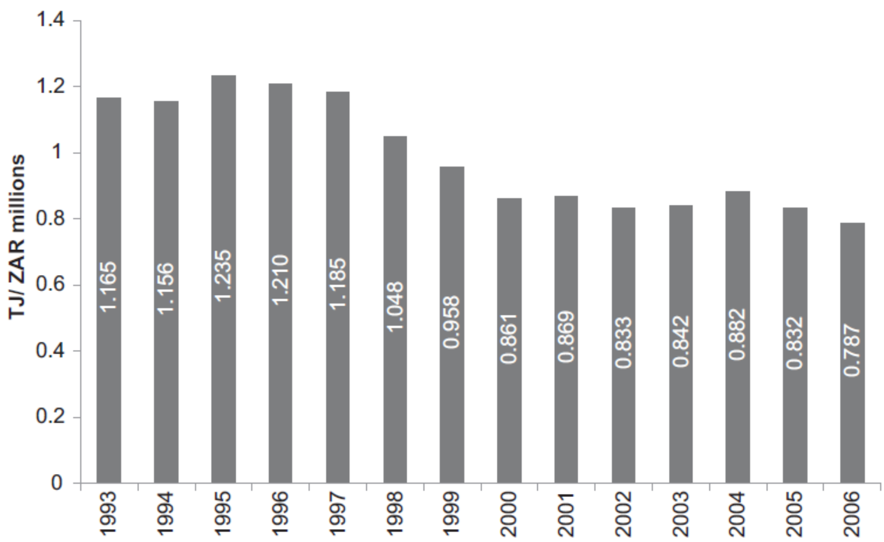

Figure 4. Aggregate energy intensity as energy consumption/GDP in South Africa: 1993 to 2006 [6]

4. Conclusion

Valuable feedback on how the data collection questionnaire was phrased and the likelihood of obtaining data on several of the key indicators were obtained after the pilot. The key issues and lessons learnt in the pilot phase of the EETMS will be employed in the scale-up phase. The aim of the EETMS is the identifying and establishing of a long term, sustainable, routine energy data collection system. Mandatory reporting for the commercial sector may be more effective potentially through a commercial sector Energy Performance Certificate (EPC). The aim of the scale-up will be to expand the coverage of the surveys. The IEA projected that global final energy consumption in buildings would increase by *30%* from 2007 to 2030 if current energy consumption practices and trends are continued [3]. Experience from Europe shows that regular registration of energy consumption data leads to an increased awareness of the consumption and also to a reduction in consumption. It is hoped that the EETMS system upon completion can also provide benchmarking information to all data suppliers and also for EPC purposes. The best way to determine the trends in energy efficiency in South Africa is by the identification of the impact of structural changes on efficiency on the country's energy intensity, which will assist policy-makers to choose the most appropriate policies in planning future energy shortfalls. The best way to determine the trends in energy efficiency in South Africa is by the identification of the impact of structural changes on efficiency on the country's energy intensity, which will assists policymakers to choose the most appropriate policies in planning future energy shortfalls. The Energy Efficiency Monitoring System being developed will provide an assessment of energy intensity reduction and the contribution of each sector.

5. Acknowledgements

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Presenter: The paper is presented by Dr. Wilfred Fritz and Xolile Mabusela

Can Information Security Produce Trust in a Public Safety Smart City Project?

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Abstract

With the growing number of people living in cities, the challenges faced by government to maintain service delivery to an acceptable standard are immense. 'Smart Cities' are a new and innovative approach that has been formulated during the past few years in order to use current infrastructure and resources more efficiently. One of the methods used to collect data in a Smart City is participatory crowdsourcing, but to be efficient, a large amount of data must be collected from participants. Trust in the system is necessary in order to facilitate this participation, but one of the factors that must be mitigated to foster trust is risk associated with the system and information that is reported. This paper investigates how this risk influences the decision of residents in East London to report public safety matters making use of an IVR system. The IVR system employed voice prompts to guide the user through the process of reporting a public safety matter. This system was chosen to include illiterate citizens in East London while cost effectiveness was ensured by controlling the duration of the call. In order to establish how the participants perceived the security of the system to influence risk and their decision to trust or participate in the study, a questionnaire was sent and completed by 361 participants who reported a public safety matter. The results were analysed making use of descriptive quantitative statistical analysis. The results indicate that the security of the system (confidentiality, integrity and availability) does impact on the risk perception of the participants. The participants indicated that privacy was important as they preferred to report public safety matters anonymously. The participants did consider the integrity of the system to be of vital importance, while the majority agree that the system must be available 100% of the time to be useful. The conclusion then is that risk is associated with both the actual system and the content that is reported.

Keywords: *Smart City, Public Safety, Security, Trust, Participatory Crowdsourcing*

1. Introduction

The population living in urban areas is increasing at a steady rate. According to the United Nations Population Fund, more than 50 percent of the world population lived in cities in 2008 [1]. Local authorities must provide services to these increasing urban communities making use of deteriorating infrastructure, limited budgets and diminishing resources [2]. While it is difficult to overcome these problems, a city must become smarter in order to make use of resources more efficiently [3].

The concept of a smart city is not new, but recently the term has been used to include Information and Communication Technologies (ICTs) that can build and integrate both infrastructure and services in a city [2]. As the term 'smart city' in this context is still relatively new, there is no common understanding of the definition among academics as yet. This is evident by the limited number of studies that have been undertaken to investigate and consider questions related to smart cities [4], [5].

1.1. Definition of a Smart City

The definition of a smart city will depend on the approach taken by local authorities to improve the city. These approaches can include improving the sustainability or performance of a city or focus on how technology is used to achieve these goals. An example of a definition that follows the first approach is that of Hall [6] who states that a smart city should monitor and integrate conditions of all of its critical infrastructures in order to better optimise its resources, plan its preventative maintenance, and monitor security while maximizing services to its citizens. This is supported by Giffinger et al [7] who define a smart city as being proactive about the economy, people, governance, mobility, environment, and living, while making use of the independent and aware citizens to provide information. In contrast to these definitions, Harrison et al [8] view a smart city as an instrumented (via sensors), interconnected (integration of data collected) and intelligent (using information to make better decisions) city. While the definitions can be used to explain what a smart city is, very little research has been done to report on the enabling or success factors that are necessary to implement a smart city initiative [2], [4].

1.2. Smart City framework

Chourabi et al [4] developed a smart city framework that considers the various factors that must be taken into consideration when implementing a smart city initiative. The framework consists of 8 core factors, as can be seen in Figure 1. The 8 factors include Management and Organisation; Technology; Governance; Policy; People and Community; Built Infrastructure and the Economy. While some of these factors are well documented, such as the technology and governance component of a smart city, others have not been reported on in literature.

There are two types of data collection methods that can be used in a smart city. The first is ‘crowdsensing’, which refers to the involuntary participation of the end-user making use of a mobile device with various sensors attached to it [18]. This type of data gathering is regarded as an invasion of privacy, as the participant do not have control over the data that is recorded. The second type of data collection method is ‘participatory crowdsourcing’. In contrast to crowdsensing, this approach is based on the voluntary participation of individuals in a project in which they report what they are observing in their immediate environment [19]. The data gathered can then be analysed in order to anticipate upcoming events or isolate problem areas [15].

One of the most important aspects of a smart city is that it involves the citizens in the management and governance of the city. By allowing citizens to participate and become more active, it provides for more informed and educated citizens. Hence, citizens are vital to the success or failure of the smart city project [4]. This aspect also remains one of the most underreported aspects of the framework [7].

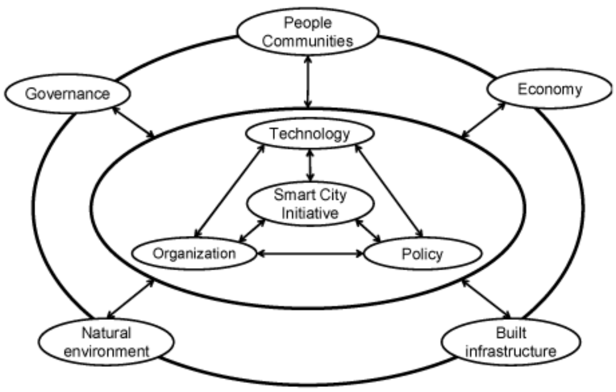

Figure 1: Smart City Framework [4]

The focus of this paper is the relationship between two of the factors in the Smart City Framework: People and Communities and Technology. The paper aims to determine how the perceived security of a participatory crowdsourcing system affects the trust relationship of citizens making use of it to report public safety matters. The remainder of the paper is structured into 5 sections. The next section discusses the theoretical basis of trust and risk that is applicable to this study. Section 3 derives the prerequisites of security that must be present to mitigate risk of the system. Section 4 defines the methodology that was used for the study while section 5 provides the results and discussion thereof. The last section addresses concluding remarks.

2. The theory of trust and risk

Stein and Harper [9] state that trust is necessary between citizens and public institutions in order to encourage participation in initiatives such as participatory crowdsourcing and e-governance. Although trust is usually associated with human interaction, in this study trust between citizens and an ICT is investigated. This is referred to as system trust and is defined as "a confident expectation in the reliability of an entity's behaviour accompanied by the acceptance of vulnerability in a potentially risky situation". This means that while trust is expected as an action on the citizen's part, a prerequisite is the perceived trustworthiness of the actual system [10].

The Integrative Model of Organisational Trust is used in Information Systems to identify the characteristics that are necessary to establish the trustworthiness of an ICT system. According to the model there are three characteristics that are needed. These include the ability, benevolence and integrity of the participatory crowdsourcing system (see Figure 2) [11].

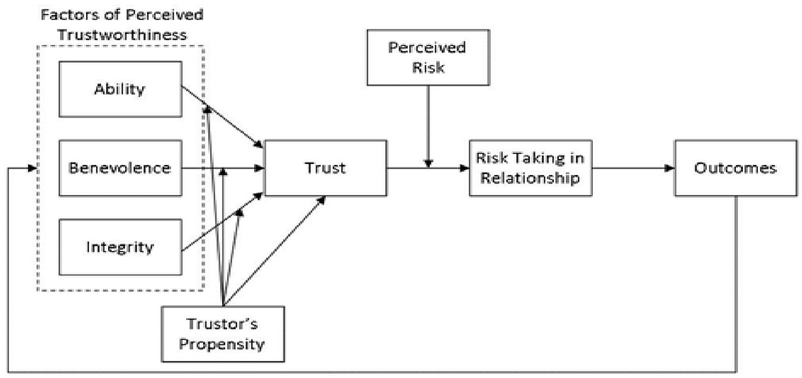

Figure 2: The Integrative model of Organisational Trust [11]

The first characteristic, Ability, is defined as the skills, competencies and characteristics that ensure the trustee has influence in the relationship [11]. In the participatory crowdsourcing system, the ability of the system to record the public safety matter reported by the participant correctly will influence this characteristic.

Benevolence is defined as the extent to which the trustee is believed to want to act in the trustor's best interest and implies helpfulness and cooperation from the trustee's side [11]. The ability of the participatory crowdsourcing system to reflect the reported public safety matter correctly and the harm that can be caused if the information was improperly disclosed to a third party contribute to this factor.

The last characteristic, Integrity, is defined as a perception that the trustee prescribes to the principles that the trustor finds acceptable. Similar terms that can be found in research include consistency, fairness and value congruence [11]. The information that is reported in a participatory crowdsourcing system must be complete, accurate and current in order to be useful.

It is commonly accepted that a 100% secure system is not feasible and that despite additional investments in controls or safeguards it will not eliminate all risk entirely. This means that the user will have to enter into a system trust relationship in order to engage meaningfully with the participatory crowdsourcing system [12]. This relationship is affected by both the level of trust and the perception of how adequate or inadequate the controls are that govern the conditions of the arrangement. In order to optimise the relationship between the user and participatory crowdsourcing system, the right balance between the trust and control in place must be found [13].

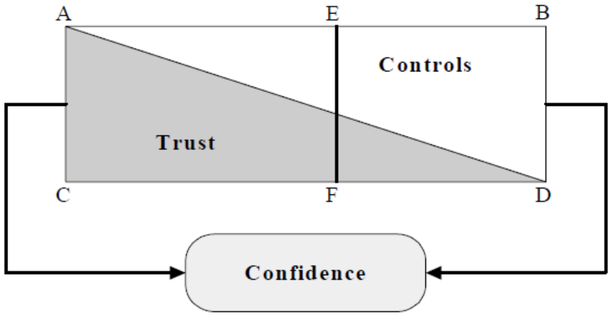

Figure 3: The relationship between Trust, Controls and Confidence [20]

Figure 3 illustrates how trust and controls work together to create the perception of security of a participatory crowdsourcing system. The rectangular area, A, B, D, C, represents the transaction or interaction between the user and participatory crowdsourcing system. Triangle A, B, D represents the Control area while triangle A, D, C represents the Trust area. The line E-F is the hypothetical positioning of the individual's Risk Appetite, the position of which can be influenced by the individual's propensity to accept risk. When considering the Risk Appetite line it is clear that the white area is protected by controls and the dark area, which presents risk, is protected by trust. This means that the confidence of an individual can be influenced by both trust and controls, but that the extent of this confidence will depend on the Risk Appetite line of the individual. As line E-F moves further left, the system controls put in place decreases and subsequently the risk (and associated trust the individual has to display), increases [13]. The next section discusses security as a control that can mitigate the risk that is associated with the system.

3. Information Security

One of the controls the user has to evaluate the trustworthiness of an ICT system is the security functions and associated privacy controls [10]. Kainda et al [14] propose that the natural way a user interacts with an ICT should be considered a secure way. The most common perception is that security information and properties are often difficult to understand. This means that this information must be provided to the citizen in an understandable way in order to allow them to form their own opinion about the trustworthiness of the ICT system [9]. This means that the user should not have to think about detailed security processes, but assume these processes are in place. This is supported by Ling and Masao [15] who suggested that in future one of the main obstacles to overcome in order to increase trustworthiness in information systems will be how to put control measures in place to protect and secure the information obtained from the user.

One of the most commonly used frameworks in ICT security is the "C-I-A triad". The 3 major objectives that must be considered when implementing a security framework in ICT include Confidentiality (preventing disclosure of communications between sender and receiver whether intentional or unintentional), Integrity (ensuring the accuracy and consistency of information as it moves through all parts of the network), and Availability (making sure that all who are authorized to access network resources are able to do so reliably and without undue delay) [14].

In order to facilitate the C-I-A triad the ISO/IEC 27002 guideline was developed. This guideline contains the best practices for control objectives and information security management. It also provides guidance and the general principles for initiating, implementing, maintaining and improving information security management in an organization [16]. The next section will discuss the methodology that was followed during the research project.

4. Methodology

In this study an Interactive Voice Response (IVR) system was developed in conjunction with IBM to allow members of the public to report a public safety matter. The IVR system is particularly suited for developing countries as it can be accessed from the most basic mobile and fixed line handsets. This means that the technology is accessible to and can be used by illiterate and low income users [17]. The IVR system directed the caller via voice prompts to record a message. The study population identified for this research project was phone users in the East London area. Residents were recruited through marketing of the system in local newspapers, distribution of flyers and social media. Ethical approval for the study was obtained from the Research Ethics Committee of the University of Fort Hare.

A quantitative data collection method was employed. A total of 485 people registered on the CSI website and was send a questionnaire to complete. From these a total of 394 questionnaires were completed. Thus, the response rate is 81.2%.

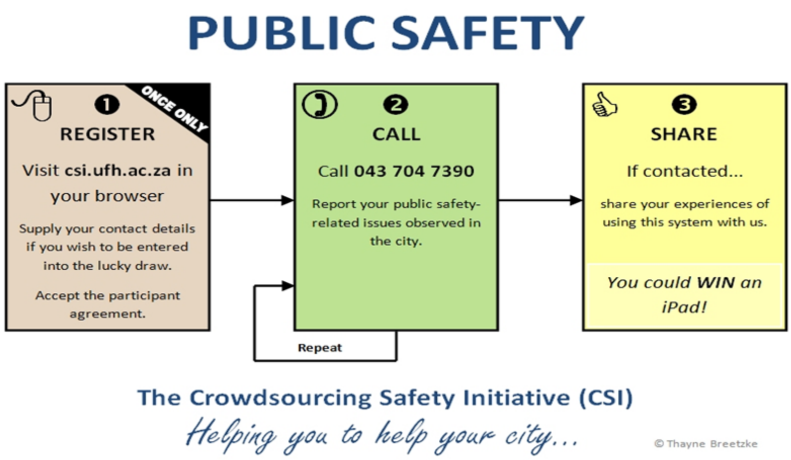

Figure 4: Steps of the Public Safety Project

Figure 4 is a graphical representation of the project. During the first step, participants had to register on the official Public Safety Initiative website and accept the terms and conditions of the project. If they chose to be included in a lucky draw competition they had to supply contact details in order to reach them. Step two was to call the provided number and report a public safety matter. Step three entailed completing the on-line questionnaire that was sent to the registered participants in order to share their experience of the system. A total of 394 questionnaires were completed, of which 361 were deemed usable after data cleaning. The next section focuses on the analysis and discussion of results.

5. Analysis and Discussion

The objective of this paper is to determine how the perceived information security of a participatory crowdsourcing system affects the trust relationship of citizens making use of it to report public safety matters. A questionnaire was sent to the registered participants who had reported a public safety matter. The following section discusses the results of this questionnaire in regards to the trustworthiness and perceived security of the participatory crowdsourcing system. The Cronbach's Alpha coefficient was conducted for the two categories, trustworthiness and security, and was found to be 0.9 for both categories. This is considered to indicate good test reliability. The factors introduced in the previous section to determine the trustworthiness of a system, Ability, Benevolence and Integrity, as well as the specific security factors, Confidentiality, Integrity and Availability, is discussed in detail.

5.1. Trustworthiness of the participatory crowdsourcing system

As discussed in Section 2, trustworthiness of the participatory crowdsourcingsystem will be determined by 3 factors: Ability, Benevolence and Integrity. The following table summarises the results that were found for these 3 factors. For each factor, 2 questions were included in order to test the specific factor. The reported intent to use the participatory crowdsourcing system in the future to report public safety matters was 82.2%. This indicates a positive response from the participants for future use of smart technology to report public safety matters.

Table 1 – Trustworthiness factors of the participatory crowdsourcing system

Category	Question	Median	Mean	Agree	Disagree
Ability	Were you satisfied that you could report your public safety matter efficiently?	2 (Agree)	1.92 (Agree)	83.62%	5.85%
	The system is able to reflect my public safety matter correctly.	2 (Agree)	1.82 (Agree)	85.27%	1.16%
Benevolence	If the information I reported was improperly disclosed to a third party, the impact for me could be negative.	2 (Agree)	2.45 (Agree)	62.5%	18.61%
	I do not worry if the information provided will be used for something other than the intended purposes.	2 (Agree)	2.7 (Agree)	56.98%	28.2%
Integrity	The information provided must be accurate and complete in order to be useful.	2 (Agree)	1.88	88.39%	2.55%
	I do not worry that the information I provided will be modified in any way.	2 (Agree)	2.58	58.98%	25%

As seen in Table 1, the participants in this study were very positive towards the ability of the participatory crowdsourcing system. The majority agreed that the system was able to do what is supposed to.

Benevolence deals with the intention of the authorities to use the system and information it contains. As seen in Table 1, both the questions in this section focused on the improper disclosure of the information that is reported to the system. The results indicate that the participants did agree that the data reported could be used for something other than the intended purpose, but half (56.98%) were not concerned about this possibility. Sixty two percent did, however, agree that if this were to happen, the impact on the individual could be negative.

Data integrity is very important when reporting public safety matters. The information must be complete, accurate, current and valid in order to be of use. A quarter of the participants indicated that they were worried that the information provided could be modified, while the majority (88.39%) indicated that the information must be accurate and complete. The next section discusses the results of the security of the participatory crowdsourcing system.

5.2. Security of the participatory crowdsourcing system

The C-I-A triad is used in this study to determine the perceived security of the participatory crowdsourcing system. The results for confidentiality, integrity and availability are represented in Table 2. For each of these factors, only 1 question was included in the questionnaire.

Table 2 - Security factors of the participatory crowdsourcing system

Category	Question	Median	Mean	Agree	Disagree
Confidentiality	I prefer to provide information anonymously	2 (Agree)	2.1 (Agree)	72.6%	5.6%
Integrity	I do not worry that the information I provided will be modified in any way	2 (Agree)	2.45 (Agree)	62.5%	18.61%
Availability	The IVR system must be available 100% of the time in order to be useful	2 (Agree)	1.8	86.6%	3.4%

The result show that the participants in the study were very concerned about privacy when making use of a participatory crowdsourcing system. The majority indicated that they would want to make use of the system anonymously. While the larger percentage of participant indicated that they were not concerned about the integrity (62.5%) of the information once reported, there was concern from some of the participants. Eighty six percent of the participants did agree that the system must be available 100% of the time. The next section discusses the results reported in this section.

5.3. Discussion

This paper set out to determine how the perceived security of a participatory crowdsourcing system affects the trust relationship of citizens making use of it to report public safety matters. Making use of the theoretical literature study and the empirical study it was found that both trustworthiness (Ability, Benevolence and Integrity), as proposed by Mayer et al and information security factors (confidentiality, integrity and availability) as proposed by the ISO/IEC 27002, must be present to ensure the successful implementation of a participatory crowdsourcing system [11], [16]. The next section discusses the elements as informed by the literature and empirical sections.

5.3.1. Perceived Trustworthiness

In the literature section a discussion was presented about the various trustworthiness factors that will build trust. The Integrative Model of Trust provides three factors as the determinants of trustworthiness – Ability, Benevolence and Integrity. Most authors in trust research agree that these factors can be used to determine the degree of trustworthiness and as a result were included in this study. These findings were confirmed through the questionnaire findings described in the empirical findings.

5.3.2. System controls

If the security controls are not in place, the participant will have to move their Risk Appetite line to the left of the rectangle in Figure 3. This means that the participant must rely more on trust with a subsequent increase in risk. As the empirical findings confirmed that the perceived security of the system is important to the participant, the security controls (confidentiality, integrity and availability) must be considered as part of this factor when a participatory crowdsourcing system is implemented.

6. Conclusion

From the literature and empirical findings, this paper proposed that both the factors of trustworthiness and information security are necessary for the establishment of trust in a participatory crowdsourcing system. This is especially important in the context of public safety where the information reported must be used to make decisions on how to respond to emergency situations and improve public safety in general.

This study has focused on the implementation of a participatory crowdsourcing system in East London, which provides an important contribution to the field of study as most crowdsourcing systems have been implemented in developed countries. Developing cities have very different challenges which must be considered when implementing crowdsourcing and this relates directly to the trust in the system and subsequent user behaviour.

7. Acknowledgements

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Presenter: The paper is presented by Liezel Cilliers

A Data Warehouse Model for Botswana Innovation Hub

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Abstract

In the 2009-2012 Botswana Information and Communication Technology strategic plan, the Government of Botswana signposted its interest in promoting Information and Communication Technologies, innovation as well as Information and Communication Technology-Enabled services with the aim of building knowledge based economy. It was against this notion that Botswana Innovation Hub was established as a science and technology park to take the advisory position in the mining technology, bio technology, clean technology and Information and communication technology sectors in the country. Creating a pool of knowledge to drive the mandate of the park is a crucial factor for the prosperity of this endeavors, hence a need to catalyze its data component, "business is data and data is business". This research wishes to demonstrate through a data warehouse model the ability to strategically support professionals and government entities with strategic information on their quest of addressing innovative, business and market ideas, questions and concerns.

Keywords: *Data Warehouse, Science and Technology Park, Business Intelligence, Extraction Transformation Loading, Sustainability*

1. Introduction

For years the economy of Botswana had been heavily dependent on unsustainable natural resources. The country proud itself worldwide with diamond mining and tourism, however it is of a great concern that these resources cannot be available for ever, therefore the government had to zoom in to new modes of income generation for a sustainable economy. In the 2009-2012 Botswana ICT strategic plan, the Government of Botswana has signposted its interest in promoting Information and Communication Technologies, innovation as well as ICT-Enabled services [1].

It was against this background that the Botswana Innovation Hub (BIH) was established as a science and technology park, the first of its kind in Botswana. BIH as a science and technology park (STP) is envisioned to be a home to several technology-oriented and knowledge intensive foreign and local business [2], a continental leader in mining technologies, Information and Communication Technologies (ICT) and ICT-Enabled services, Biotechnologies and the Energy and Environment technologies as well as the supporting knowledge intensive business services (KIBS). The park will catapult Botswana into information and knowledge based economy through the establishment of knowledge, technology-based business as well as relevant research and development (R & D) activities in the previously stated sectors.

To fully manifest this mandate, BIH should be wholly data driven in order to inform new technologies and provide rationale for new innovations beyond a reasonable doubt. The modern era dictates that data is business and business is data. As the facilitator and advisor of this stature, the hub needs to adjust its information management component to have the ability to address strategic question on behalf of the country.

This research therefore wish to develop a data warehousing model to demonstrate the influence of data in the advisory position in the economy of the country as BIH assume an eminent role to catalyze and catapult Botswana in to a knowledge based economy.

To demonstrate such, the following strategic questions must be address by the data component of the park as it shall be demonstrated by the proposed model;

- Forecasting the market sustainability of companies and researches carried out in the hub with a stipulated time frame
- Determine the feasibility of products and/or Research and Development in the market segment with respect to the regional and international competitors.
- Exploring ways in which a given company in the hub or a newly established entity can improve and increase its market share and new opportunities given the products trends.
- Establishing why are profits on a declining and ways to counter measure.
- Explore ways in which BIH can strengthen its equity in the internationally platform as well as sub-Saharan region as the best technology hub in Africa.
- Which services and product are being more profitable and how well can we manage and sustain them.
- Improve customer relationship policies to retain its stakeholders and also attract new ones in to the hub.

2. The Role of Science Parks (STP)

STP's as defined by [3] are organizations managed by specialized professionals, whose main aim is to increase the wealth of their communities by promoting the culture of innovation and the competitiveness of its associated businesses and knowledge-based institutions. Sometimes named innovation hubs, Science parks fulfill a key role in nurturing commercial and technological innovation in various countries.

Innovation hubs have been proposed recently across different African countries with the sole intention of creating knowledge based economies. The Innovation Hub in the University of Pretoria (UP) [4] is one of the few African internationally accredited STPs. The smart village park in Egypt enables a hassle free business environment through creativity, innovation and business development, [5]. Tunisia is an African idol in science and technology development as indicated by the 2010 – 2011 Information Technology report, [6]. In 2002, Tunisia established Sidi Thabet Biotechpole as a Centre of biotechnology applied in health and pharmaceutical industries. The Silicon Valley located at the campus of Stanford University in America is one of the partriotes in the concept of science parks [7]. In the great Europe there are science parks such as the one in the Heriot-Watt University in Scotland and also in Cambridge University to mention the few. In his paper, Raymond observed that science and technology parks (STPs) seem to be the proper stop gap solution for most developing and emerging countries more especially in the African continent [8].

3. Data Warehouse Technology

A data warehouse model is envisaged to position BIH abreast of the curve in the advisory with a vast amount of data generated from various institutions such as academia, research centers, private companies and government entities [2] A Data warehouse is a Business Intelligence (BI) Tool, [9] defined BI as a process by which users can obtain accurate and consistent business data from the enterprise data warehousing environment, analyze this data from different business contexts, identify trends, variations and anomalies, execute simulations, and obtain insights about business problems or business opportunities that enable them to perform faster and make more informed decisions. BI technology encompasses, data mining techniques, data visualization, data integration as well as data warehousing (DW) among other technologies.

Commonly associated with DW is the dimensional modeling (DM) process. DM is a data warehouse design technique for databases intended to support end-user queries in a data warehouse [10]. It is oriented around understandability and performance. Data Warehouse provides a technological infrastructure enabling business organizations to extract data from source systems, cleanse/scrub the extracted data, and transform enormous amounts of data to be stored in it [11] through a process known as ETL (Extraction, Transformation, and Loading).

In the ETL process, data cleaning requires filling in missing values, smoothing noisy data, identifying or removing outliers, and resolving inconsistencies before loading it to the data warehouse. This is a systematic and an imperative activity in populating the data warehouse and therefore it needs to be done with caution and diligence, to ensure data quality and data integrity.

DW had been used over years by various institutions with diverse mandates. One example of a data warehouse system is the Stibo Systems which enables its customers to better manage enterprise intelligence on a global scale, improve sales, and quickly adjust to changes in business requirements [12]. Data warehouse has been in used over several years now and amid the renowned pioneers of the technology is Teradata. Teradata Labs facilities located in San Diego, services prominent names of the modern era driven by radical data analysis philosophies such as Walmart, Apple, eBay and Continental to mention the few as highlighted by [13]. Apple uses a multi petabyte Teradata data warehouse that helps the company to get a better understanding of its customers across product groups [13]. It is amazing how data warehouse technology had managed to upsurge its terrains and revolutionizes data management with big sharks such as Avis Europe taping in to the benefit. The marketing team at Avis Europe has been quick to use the new customer-centric view of information in innovative and creative ways to extend their market shares as indicated in the SyBASe website [14]. Evidently, DW technology plays a very crucial role in the decision making and business advisory positions hence why this research wishes to ride in to address some strategic issues in the park, BIH.

4. Proposed Data Warehouse Model for BIH

4.1. Methodology

Several interviews and open discussions were conducted with Botswana Innovation Hub representative to position this research appropriately in line with the needs of the science park.

Other stakeholders such Botswana Export and Development Agency (BEDIA) and International Financial Services Center (IFSC) were also consulted and sensitized about the benefit of this endeavor on their business model and their roles in this research will be discussed. In an interview with BEDIA BotsJobs web portal and BEDIA companies' data base were identified to be the data sources. Several literatures such as a research paper by [15] were used to provide data for this research.

On every meeting that was conducted captured minutes were discussed and consolidated in to the research paper by the researchers involved in this research work. Fortnight discussions between researchers were conducted to analysis the progress of the research and action task assigned for the next step identified.

4.2. Dimensional Modeling for the Sustainability Problem

This research wishes to demonstrate a data warehouse model through a response to the following strategic question: 'Establish the sustainability of ICT services in Botswana in terms of its demand and market share and skill level needed to provide such services'.

Sustainability can be referred to as the ability to accommodate the demand of the recent generation without compromising the resources of future, and other literature define sustainability as the ability to endure and remain durable through different circumstances, hence this research opt to use of the latter definition. Sustainability is a function of various elements such as service demand, market demand as well as skill availability. To articulate this research question, this research would adopt Kimball's Bus architecture, the star schema, **with the following dimensions**; market demand, service demand, skill demand and socio economic contribution as dimensions as well as sustainability as a fact as shown in figure 2 below.

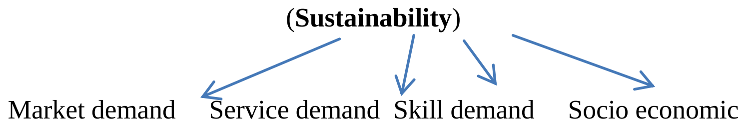


Figure 1: Measures of ICT services sustainability

Skill Demand

In determining the skill readiness of Botswana's industry, this research sought to discuss certain criterion that indicates the level of demands for certain skills as well as availability of relevant personnel.

Service Demand

Service demand dimension intend to identify those services that are of high demand both locally and internationally. The type and quality of services offer by an organization is key in the sustainability of such an organization and it can be measured against different factors that define sustainability.

Socio Economic Contribution

How much does a given service contribute to the socio-economic factor of the country is equally a crucial point to consider when modeling the sustainability of a service. For example, if we can ascertain the impact of a given ICT service towards an education sector or a manufacturing sector, a conclusion on its sustainability can be drawn. This dimension therefore intends to determine and measure the economic value and the socio economic contributions of different services.

Market Demand

Market can be defined as a group or a population of targeted consumers of a product or service. It is usually influenced by many factors such as demographic factors, size of the targeted segment, cultural factors, buying power of the community as well as awareness of the product in the area.

Table 1: Converting Strategic Queries into target dimensions

Skill Demand	Market Demand	Service Demand	Socio Economy
This dimension intends to help in the following: • What skills are available locally to support which services? • How effectively can skill mismatch be addressed? • What skills are in great demand?	Understanding the market demands and needs is a prerequisite in position a product or service hence the relevance of this dimension. ✓ How well can a product be position and who are the potential targets?	This dimension aims at analyzing different services that are offered by different industries against potential services. • Where do we find such services? • Who are the players in the industry? • How is it performing in the market?	This dimension therefore intends to determine and measure the economic value and the socio economic contributions of different services. ✓ How well would the community benefit from a service?

4.3. The ETL Process

4.3.1. *Data* Extraction (Skill_Demand Dimension)

Botswana Innovation Hub is mandated with the responsibility to revolutionize the country's natural economic drivers towards the knowledge based economy as underlined by this research. In order to realize the latter, this research seeks to demonstrate through a typical ETL package issues associated with the sustainability of ICT services within the country. Strategic data is extracted through the ETL process from different sources discussed in the above sections using Micro soft Business intelligence studio. Shown in figure 2 below is a typical star schema demonstrating the potential dimensions for the BIH data warehouse, however this research exemplify the process with the skill demand dimension only.

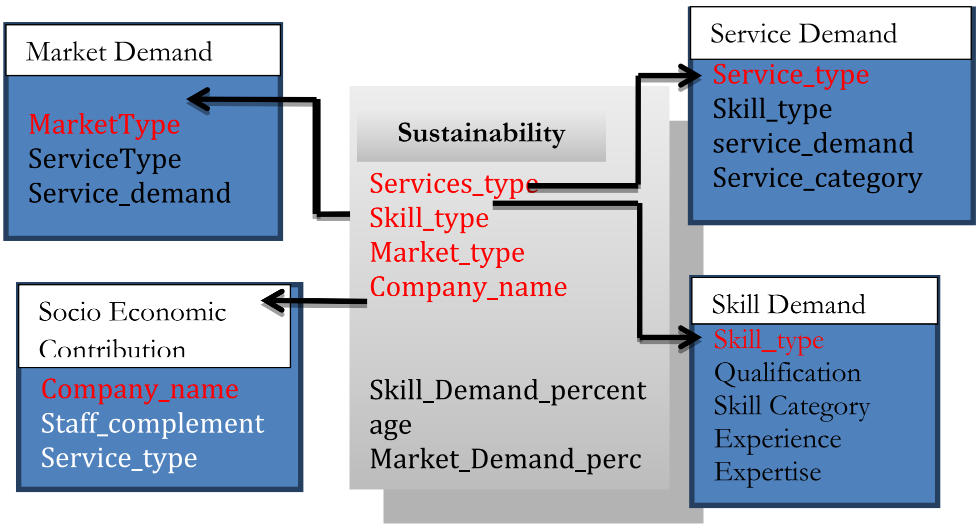


Figure 2: A star schema

Figure 3 - 6 demonstrate a typical extraction transformation and loading process using the skill demand dimension.

Skill_demand Dimensions Schema-{Skill_type (PK), Qualification, Skill Category, Experience, Expertise, Professional Trade, Institution, Qualification}

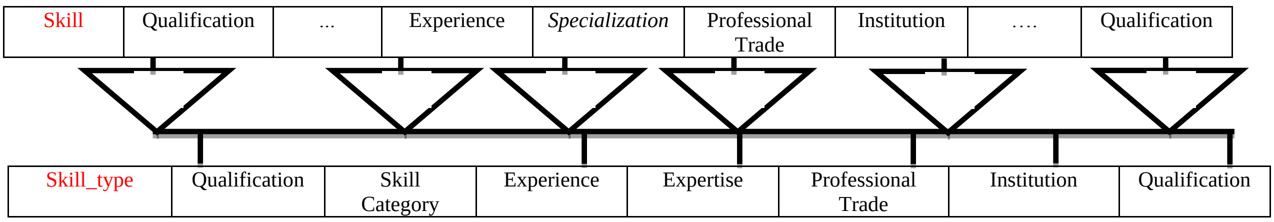


Figure 3: Direct mapping transformation (1:1 relationship)

Dimension skill demand sources some of this data as shown by the direct transformation in figure 4 below from various tables articulated in the master's thesis that support this research paper as well as from other researches such as the one by [12] and other BIH allied partners and stakeholders.

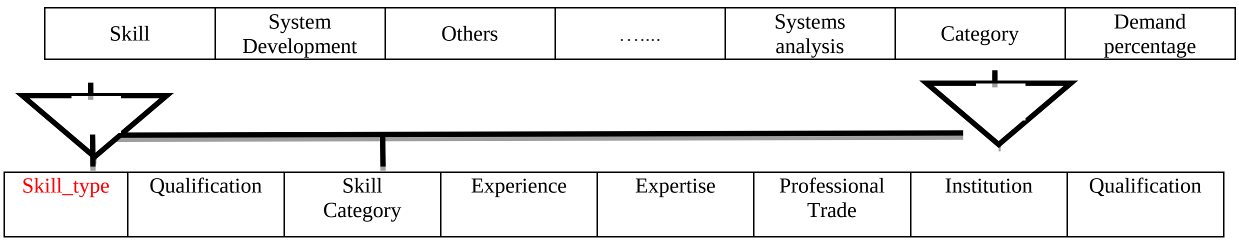


Figure 4: Direct transformation

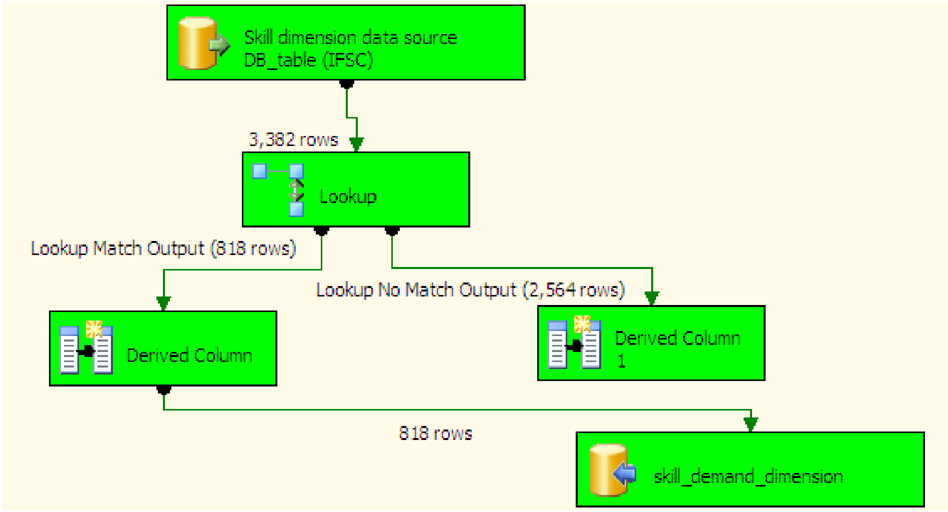
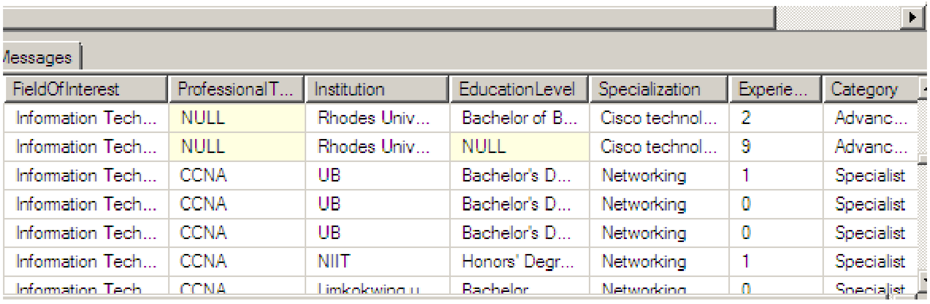


Figure 5: Skill Demand Dimension Transformation Process



FieldOfInterest	ProfessionalT...	Institution	EducationLevel	Specialization	Experie...	Category
Information Tech...	NULL	Rhodes Univ...	Bachelor of B...	Cisco technol...	2	Advanc...
Information Tech...	NULL	Rhodes Univ...	NULL	Cisco technol...	9	Advanc...
Information Tech...	CCNA	UB	Bachelor's D...	Networking	1	Specialist
Information Tech...	CCNA	UB	Bachelor's D...	Networking	0	Specialist
Information Tech...	CCNA	UB	Bachelor's D...	Networking	0	Specialist
Information Tech...	CCNA	NIIT	Honors' Degr...	Networking	1	Specialist
Information Tech...	CCNA	Limkokwing u...	Bachelor...	Networking	0	Specialist

Figure 6: Loaded Skill Demand Dimension

The aim of dimension shown in figure 6 above is to address the skill proficiency of Botswana's graduates and determine the gradation of professional pool in the country as per the mandate of BIH. Identifying the area of specialization and the educational level will enable the park to analyze the aptitude of the available brainpower essential to sustain certain services as this research seeks to illustrate, hence advice in terms of economic tolerance.

All the others dimension went through the same Extraction Transformation and Loading process from their relative data sources.

5. Discussion and Conclusion

Through the dimensional modeling process, the identified dimensions were populated with data from various source and then mined for knowledge discovery in order get answers to several more strategic question as this research seek to achieve. Table 2 below discusses and analyses some finding and their implication in the sustainability of various services offered by the industry.

Table 2: Discussion on how the dimensions affect sustainability of services

DIMENSIONS	RESULTS	IMPLICATION ON SUSTAINABILITY
Skill demand dimension	✓ From the dimensional table in figure it shows that there are more professionals with CCNA certification. ✓ It also appears that majority of graduate specializing in networking are University of Botswana graduates. ✓ Professionals Skills like Cloud computing, Artificial intelligence and Business Intelligence are still scarce in the industry.	✓ Networking services have high number of readily available skilled personnel whilst services that requires skills such as cloud computing among others might run in to the risk of failure due to lack of relevant skilled manpower.
Service demand dimension	✓ Services such as telecommunication and IT consultancy have high demand. ✓ These services create more employments to the local community.	✓ Telecommunication and IT consultancy services are more sustainable as they have high demand to a vast market.
Market demand dimension	✓ Telecommunication and IT Consultancy are the most prominent services in the industry and they have a high market demand.	✓ Telecommunication and IT consultancy services are more sustainable as they have high demand to a vast market
Socio economic contribution dimension	✓ Telecommunication services create more employment than other services.	✓ Telecommunication is a sustainable service.

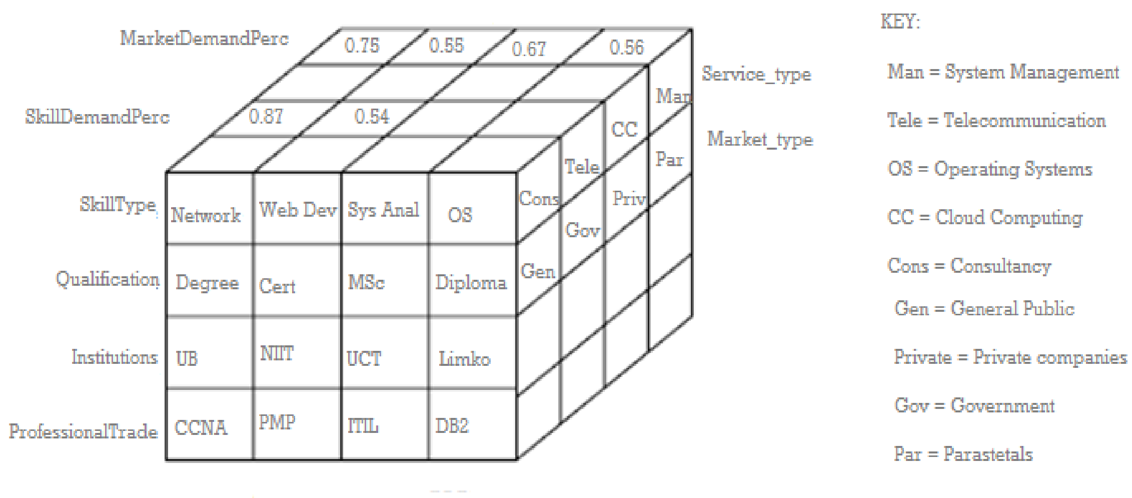


Figure 7: The Sustainability Cube

From the cube in Figure 7 above, it can be seen that data can be analyzed from different angles. The data warehouse technology allows us to view and dig through the data warehouse data in 3 dimensional format. In the cube above it can be analyzed that 0.87 networking professionals get hired in the telecommunication industry. A lot of strategic information can be extracted from this cube to guide the decision making process. For example networking and system analysis skills are significant in management positions and these services have higher market demand. This information shall help in informing both the research institutions, start-ups and spin offs on the level of personnel available to support their services as well as to inform academia on the relevance of the courses they offer.

In conclusion it is evident that strategic data management is an inevitable aspect in science and technology setup in order to efficiently drive the mandate of creating a pool of knowledge as this research seeks to demonstrate.

6. Acknowledgement

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Presenter: The paper is presented by Audrey Masizana-Katongo and Otlaathusa Ramasimong

Challenges Facing Teleradiology in the Eastern-Cape Public Health Service: An IT Technician Perspective

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Abstract

Telemedicine has made great strides in the developed world with remote populations benefiting from the improved access to healthcare. In particular, the sub- field of teleradiology has shown great promise for enabling the wider delivery of specialist services. However, in resource constrained settings such as developing countries, telemedicine has had limited success and as a result, the equitable access to healthcare for remote populations remains inconceivable. This is exacerbated by the migration of healthcare professionals both domestically and internationally. The public sector has suffered the most with acute staff shortages in the public healthcare institutions, more so in rural and remote areas. This paper presents the challenges facing the adoption and growth of teleradiology, a sub component of telemedicine, in resource constrained settings from the perspective of the IT technicians involved in the service delivery. Four IT technicians from different institutions and operating backgrounds within the Eastern Cape were selected for participation in semi-structured interviews and a methodological triangulation with literature was conducted. The results thus far point to an enthusiastic environment coupled with a semi-capable infrastructure but however hampered by staff shortages and a general lack of propulsion to adequately encourage the wider use of teleradiology.

Keywords: *Teleradiology, Eastern-Cape, Technical Perspective.*

1. Introduction

The recent advances in the Information and Communications Technology (ICT) field have had a profound effect on the accessibility of medical services, primarily in previously remote and disadvantaged areas. However, South Africa, and the rest of Sub-Saharan Africa face a critical shortage of medical practitioners and specialists. [1]. This problem is most persistent in Africa and its effects are particularly severe in the public sector. The shortage of health workers and medical practitioners can be attributed to a large range of factors including the persistent movement or 'brain drain' of health workers from the less developed countries [2]. The public sector employs the majority of the health workers in developing countries and as a result, factors such as budgetary constraints and poor working conditions usually associated with the public sector are a significant contributor to the migration [3]. The migration flow of health professionals can be summarized by the push, pull and stick effects as illustrated below [4]

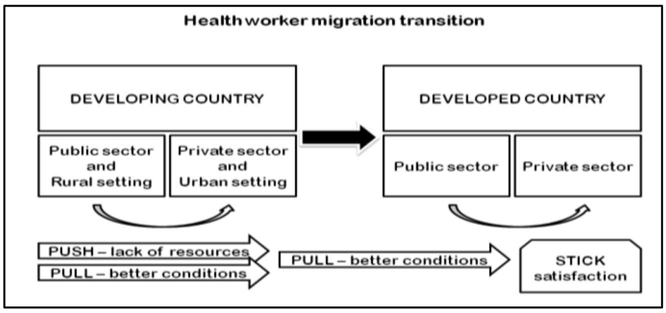

Figure 1. Push and pull factors driving migration.

As an indication of the scale of this problem, in 2010, the WHO adopted a global code of practice on the international recruitment of health personnel with a focus on ethics and protecting less-developed countries from the open-ended migration cycle [5]. In 2006, the World Health Organization identified 57 countries with a critical health worker shortage and of these, 36 were from sub-Saharan Africa [6]. The shortage of health care practitioners particularly in resource constrained settings has resulted in a growing demand of service delivery alternatives to supplement the existing service delivery channels. Telemedicine is an ICT based service that can be used for the remote delivery of healthcare thereby allowing for wider access to medical specialist services such as radiology.

Teleradiology has been used in an excess of 20 sites in the Eastern Cape which is known to be the poorest province in South Africa. These services have the potential to deliver both economic and healthcare wins in rural communities, however, capacity problems and the general lack of support for telemedicine as a whole has had a negative bearing on the success of teleradiology in the Eastern Cape. In this paper, teleradiology and the challenges faced in its deployment and use in the Eastern Cape are explored. In Section 2 of the paper telemedicine and teleradiology are discussed and the various applications and typical use scenarios are identified. This is followed by a brief discussion of the theoretical grounding and methodological approach of the study in Section 3. The results of the study are presented in Section 4. The paper ends with a discussion of the results in Section 5 and a set of recommendations going further in Section 6. Telemedicine and teleradiology are further discussed in the following section.

2. eHealth, Telemedicine and Teleradiology

EHealth can be defined as "*the cost-effective and secure use of information and communications technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research*" [7]. Telemedicine is a constituent of eHealth and teleradiology is a sub-service of telemedicine. Narrowing down from the definition of eHealth, telemedicine can be described as the use of telecommunications technology for medical diagnostic, monitoring, and therapeutic purposes where distance and/or time separate the patient and health care provider [8].

Telemedicine emerges as a potential solution for the shortage of heath care workers and specialists by providing a means for the delivery of health related services to isolated rural areas [9]. Telemedicine has also been noted to have an economic impact on rural communities resulting from reduced travel (lower transportation costs) and greater productivity due to the decrease in missed work time, additionally; it offers employment opportunities within the communities stemming from the increased local laboratory and pharmaceutical activity [10].

Presently, telemedicine has applications in clinical, educational and administrative services. The table below provides a general overview of these applications.

Table 1. Applications of telemedicine [9].

APPLICATION	STORE AND FORWARD	REAL-TIME	SERVICES
CLINICAL	Digital images may be sent via e-mail direct to the specialist for diagnosis and management advice	Videoconferencing may be used for clinical consultations involving the patient, Primary care provider (General Practitioner) and specialist at a tertiary hospital	Telepathology Telepaediatrics Teledermatology Teleradiology Teleultrasound Teleophthalmology Teledentistry
EDUCATIONAL	Educational material can be sent by mail in the form of tutorial notes, audio or video resources	Lectures can be transmitted via videoconference to multiple sites simultaneously	Teleproctoring Telementoring
ADMINISTRATIVE	Memo and meeting notes may be mailed by post or fax for perusal at a time that is convenient for the recipient	Telephone conferencing may be used for interactive discussions between participants	Teleconferencing Tele-collaboration

Teleradiology is a Store and forward application of telemedicine. These applications typically have low infrastructure and connectivity requirements that render them particularly suitable for the delivery of rural and remote health care. Teleradiology can be described as the ability to obtain images in one location, transmit them over a distance for diagnosis at a different location and has been cited as one of the most technologically and clinically advanced areas for telemedicine applications [11].

Teleradiology projects have been attempted in South Africa and were one of the primary focus areas in the telemedicine strategy [12]. A number of research projects have been conducted in the Eastern Cape with the aim to determine the development of, and challenges facing eHealth and telemedicine. The focus of this paper is to determine the specific challenges facing teleradiology as a service in the Eastern Cape public health sphere.

3. Methodology

This study took a qualitative approach so as to obtain an in-depth understanding of the day-to-day activities surrounding teleradiology from the perspective of the IT Technicians. Interviews were deemed as an appropriate method of obtaining an open, real-world view from the participants'.

3.1. Theoretical grounding

The Technical, Organisational, Environmental framework (TOE) is an organisational level theory that explains how the three elements (Technology, Organisation, Environment) may influence a firm's technological adoption decisions [13] and is depicted in figure 2.1. It has further been described as a useful analytical framework that can be used for studying the adoption and assimilation of different types of IT innovation [14]. The framework was used in this research as a template on which the interview questions were structured. The TOE framework is additionally used in the process of identifying the challenges and barriers associated with each dimension of the assimilation process.

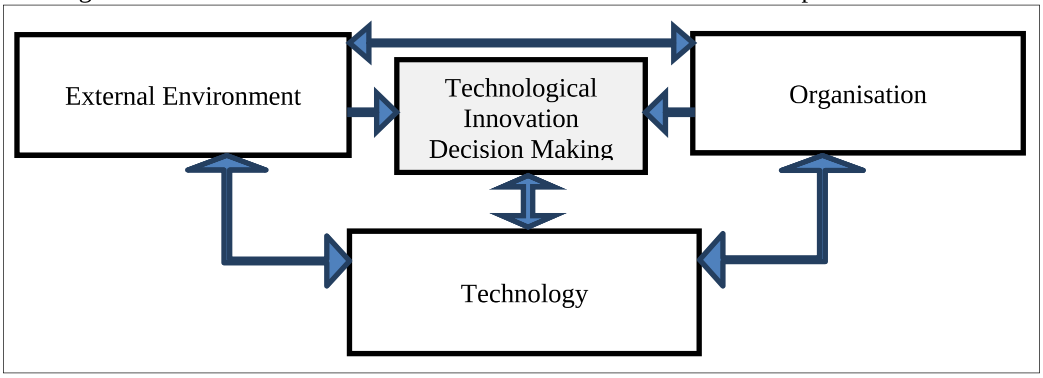

Figure 2. T.O.E Theoretical framework

3.2 Research process

The research process is depicted in figure 2.3 and is explained in detail thereafter.

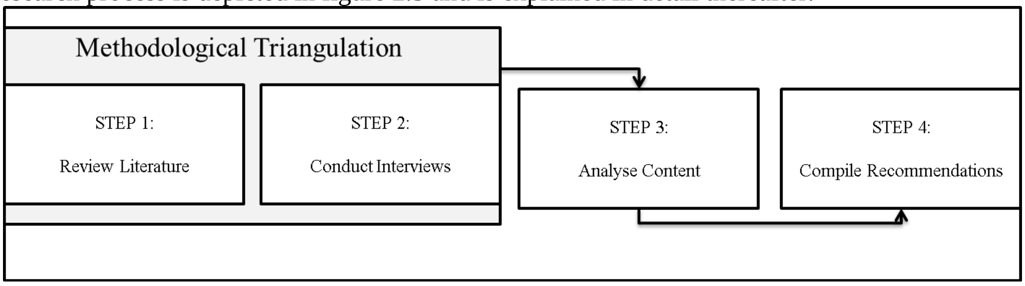

Figure 3: Research Process

In Step 1: A literature review was conducted to establish the state of telemedicine or telemedicine related services within the Eastern-Cape. Additionally, the literature review was used to identify the challenges that have already been identified in preceding research findings relating to the broader telemedicine. These challenges provided a foundation on which an interview questionnaire was drafted.

In Step 2: Following the drafting of the questionnaires from step 1, the four IT Technicians who had collective experience in at least 25 institutions where teleradiology had been implemented using the PACS system, were approached for participation and interviews were conducted.

In Step 3: The collected data was then analysed and challenges pertaining to teleradiology identified.

In Step 4: Recommendations on how to overcome or ease the impact of the barriers and challenges identified in steps 1 and 3 were compiled.

4. Results

The table below summarises the results from the interviews and also provides an indication of whether the identified barriers have been cited in the literature surveyed for this study.

Table 2. Challenge identification by participants

Factors	Literature	1	2	3	4
5.1 Technological					
5.1.1 Inadequate information security measures	N	N	N	N	Y
5.1.2 Telecommunications infrastructure	Y	Y	N	N	Y
i. Slow and intermittent connectivity	Y	N	N	N	Y
ii. Lack of equipment	Y	Y	N	Y	Y
iii. Equipment Theft	N	Y	Y	Y	Y
iv. High Equipment failure rates	N	N	N	N	Y
v. Lack of routine maintenance	Y	N	Y	Y	N
5.2 Organisational					
5.2.1 Skills availability and training	Y	Y	Y	Y	Y
5.2.2 No clear-cut responsibility domains	Y	N	Y	N	Y
5.2.3 Resistance to change	Y	N	N	N	N
5.2.4 Finance and sustainability	Y	N	N	N	N
5.2.5 Lack of Needs assessment planning	Y	N	N	N	N
5.2.6 Change management issues	Y	N	N	N	N
5.2.7 Lack of sound evaluation planning	Y	N	N	N	N
5.3 Environmental					
5.3.1 Cost of telecommunications	Y	N	N	N	N
5.2.2 Lack of legislation, policy and guidelines	Y	N	N	N	N
5.3.3 Inadequate power supply	Y	N	N	N	Y

The results summarise the individual perspectives of the participants and indicate the prevailing challenges in each of their operating environments. The prevalence of technological barriers may be attributed to the sample group selected for interviews. The technicians are likely to be more technologically inclined and hence more aware of challenges specific to their area of expertise.

5. Discussion

The challenges identified have been categorized accordingly in the TOE framework as shown in figure 4. The framework further displays the interaction of the different factors.

5.1 Technological factors

5.1.1 Inadequacy of information security measures - The ever-present concern regarding the security of patient information is a significant technical challenge. A participant mentioned that basic authentication techniques are employed in some institutions. Additionally, there is a tendency to share a single user account and password which further compromises the system.

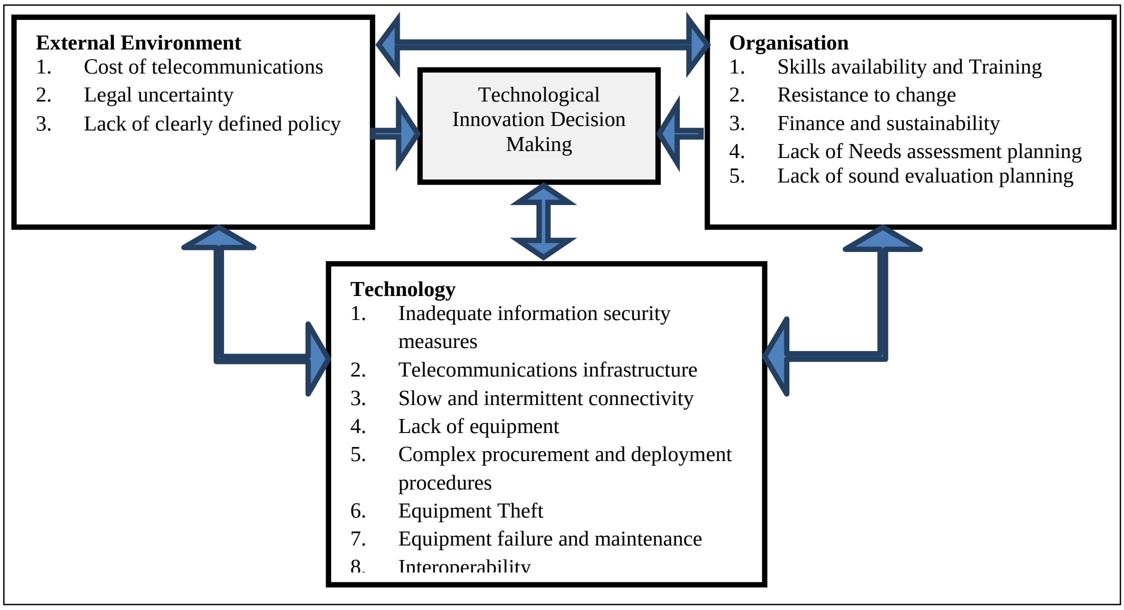

Figure 4. Populated TOE framework diagram

5.1.2 Telecommunications and infrastructure – Poor telecommunication infrastructure development in rural areas generally hinders the portfolio of services as well as the quality of services that can be availed to these communities. The following are challenges associated with telecommunications and infrastructure:

i. Slow and intermittent connectivity introduced frustrating levels of latency.
ii. One of the participants cited a shortage of workstations in the wards which results in doctors having to walk longer distances to access the images on the system thereby consuming time and requiring more effort on the part of the doctor.
iii. Equipment and cable theft, especially in rural areas may leave systems non-functional for extended periods due to the unavailability of technical staff, thereby resulting in a halt in service delivery
iv. High rates of equipment failure were cited to be partially responsible for the loss of data.
v. Maintenance and handling issues were also identified, the mishandling of equipment in some institutions results in unnecessary and unwarranted down time.

5.2 Organisational factors

5.2.1 Skills availability and training - The shortage of skilled workers has a negative effect on both the current and prospective services. Training strategies differ at each institution with some being proactive and others reactive. Few institutions have dedicated IT personnel and the few that do in many cases only have one. This problem is exacerbated in the rural institutions (which constitute the majority) where it is difficult to get IT personnel to visit and resolve any computer or network related problems; as a result, downtime can be for extended periods.
On the other hand, the practitioners themselves have experienced problems with opening multiple reports for cases with multiple exams as well as knowledge on manipulating images to clarify the display. Additionally, doctors seem to receive little training on using the system as cited by one respondent. Intern doctors typically have to learn how to use the system from doctors who have made use of the system previously.

5.2.2 No clear-cut responsibility domains - The different role-players involved in the delivery of teleradiology introduce a responsibility conflict. The department of health owns the servers and connectivity equipment which are maintained by the in-house IT technicians (if available) and lean on supplier provided warranties in the case of hardware failure. However, the PACS software running on the systems is administered by a different entity. One of the participants indicates that there is no PACS administrator; a role he believes should be attended to. As a result, when a fault occurs, there is no direct line of responsibility and this may create confusion when it comes to maintenance.

5.2.3 Resistance to change - The introduction of telemedicine related activity brings about changes in the day-to-day operations of the system users. If not properly introduced, these changes may be deemed a nuisance by those who have to change or make amendments to their style of work. Additionally, teleradiology must be seen to be replacing some established methods and not introducing additional workloads. Enthusiasm seems to be high on the part of the practitioners; however, the various technical challenges frustrate the experience thereby casting doubt on teleradiology.

5.2.4 Finance and sustainability - Finance and sustainability is both an environmental and organisational factor and the lack of resources for hospitals pose as a barrier for the implementation of telemedicine. It is as a direct result of inadequate planning of sustainability that the hospitals have lack of resources. Governments are only able to fund for a few African telemedicine activities and as such, it is important for hospitals to have careful sustainability plans for their projects to ensure the longevity of these projects. Funding for the public health sector in South Africa is received through government provisional departments of health and this leads to lack of human and financial resource commitments to hospital projects. Furthermore, the lack of sustainability of projects is a result of failure to incorporate the telemedicine projects into the daily activities of the department of health. It seems that the unsustainability of projects is seen as a major challenge for telemedicine in developing countries.

5.2.5 Needs assessment Planning - Before embarking on telemedicine projects, there is need for assessment which helps with identifying the services resources and activities required for the project. The lack of needs assessment planning poses as a barrier to the effective implication of telemedicine projects.

5.2.6 Evaluation Planning - The lack of trial and evaluation data as well as the lack of published results and shared experiences as a challenge. This hampers the ability of future projects to benefit from the lessons learnt from those that precede. Without a knowledgebase of lessons learnt and success factors identified, the propagation of successful telemedicine systems will be laden with barriers.

5.3 Environmental Factors

5.3.1 Cost of Telecommunications – This is an external factor which is complex to address. It has been suggested that mobile telecommunications infrastructure in Africa is too slow and expensive for internet connectivity. Furthermore Telemedicine is highly dependent on the telecommunications infrastructure. The high cost of telecommunication has a definite impact on the overall cost of implementing telemedicine. Telecommunication costs alone historically have been known to render telemedicine projects unsustainable.

5.3.2 Lack of policy, legislation and guidelines – Collaborative work in telemedicine activities may raise many legal questions with regards to the medical information transmitted in multimedia form. Additionally, issues of malpractice liability and remuneration crop up. The lack of a clear definitive policy regarding the legal aspects may result in increased uncertainty among both healthcare professionals and the consumers.

5.3.3 Inadequate power supply – The unreliability of power supply, especially in rural areas poses a big challenge. Effectively, scheduling becomes problematic and on-going activities are interrupted thereby wasting time and resources. Additionally, the lack of power denies the communities of the services they may require thereby losing the trust of the communities as well as that of the system users.

6. Recommendations

The table below shows a summary the compiled recommendations for each factor identified. Additionally, the intent of the prescribed recommendation is detailed in the aim column. These recommendations may play a role in either overcoming or alleviating the impact of the challenges. However, the environmental challenges are complex to resolve as the authority with the ability to effect changes is removed from the internal organization. Other environmental factors are fixed as a common characteristic of the general environment in which the institutions are established. Changes would have to be far reaching beyond the scope of the institutions.

CHALLENGES	RECOMMENDATIONS	AIM
5.1 Technological		
5.1.1 Inadequate information security measures	Information security awareness campaigns	Alert staff on the Importance of information, obligations and repercussions of mishandled information.
5.1.2 Telecommunications infrastructure:		
i. Slow and intermittent connectivity	Public-Private-Partnerships	Take advantage of Service Level Agreements to ensure high service levels
ii. Lack of equipment	Public-Private-Partnerships Lease rather than buy	Reduce start-up costs and maintenance burden while enjoying shorter upgrade cycles
iii. Equipment Theft	Secure infrastructure Access controls	Effective barring of unauthorised personnel and accountability for any equipment related movements
iv. High Equipment failure rates	Pre-emptive maintenance Redundancy	Ensure the availability of duplicate information in the event of a failure
v. Lack of routine aintenance	Third party contracts	Abstraction of maintenance burden onto third party or lessor
5.2 Organisational		
5.2.1 Skills availability and training	Decentralised staffing	Ensure the availability of adequate workers where most required
5.2.2 No clear-cut responsibility domains	Effective dissemination of structured organisational charts	Ensure every staff member can trace the service channel with ease and that support call is always logged with the correct entity
5.2.3 Resistance to change	Change management strategies	Will gradually usher in new approaches and techniques whilst being sensitive to the learning process and role of established practices
5.2.4 Finance and sustainability	Effective project business models	Ensure teleradiology projects make business sense and are not just an

		expense
5.2.5 Lack of Needs assessment planning	Effective bottom-up requirements planning	Allow the requirements to filter up from the system users on the ground.
5.2.6 Lack of sound evaluation planning	Establish a knowledge base from tried and tested projects	Reduce the duplicity of previously identified errors and pre-empt previously identified challenges
5.3 Environmental		
5.3.1 Cost of telecommunications	Difficult to address this factor	
5.3.2 Lack of legislation, policy and guidelines	Internal policy	The use of in-house policy based on internationally accepted practices
5.3.3 Inadequate power supply	Backup alternative power sourced like UPS and generators	Will allow for proper shutdown in the event of a failure and generators can be used ad-hoc for critical cases when there is no power

7. Conclusion

In conclusion, teleradiology is an essential service that has the potential to address a vast amount of the radiology needs in the Eastern-cape public sector. Teleradiology typically has lighter requirements on the telecommunications infrastructure and has been cited to work well in rural settings with minimal connectivity. However, in addition to budgetary constraints, a host of technical challenges have been identified. These challenges had a constricting effect on the satisfactory use of teleradiology. Although teleradiology is expected to have lighter requirements on the communications infrastructure, the prevailing conditions have not been adequate for the effective management of the high image volumes. Technicians have cited the slow connections, power availability, equipment availability and theft as well as maintenance problems as major technical barriers. Staff shortages along with blurred lines of responsibility emerge as organizational constraints while the availability of a stable power supply is an external factor that has a crippling effect on service delivery. Awareness campaigns have the potential to address some information security concerns by cultivating a culture of awareness and accountability. In addressing the technological and infrastructural concerns, the private sector may have a role to play. A more flexible budget in the private sector will allow for more targeted spending and development. Strategic equipment procurement may result in lower setup, maintenance and upgrade costs thereby reducing the burden on an already overstretched staff complement. Well defined organizational structures coupled with effective organizational planning will certainly see the prospects of successful teleradiology projects grow in the Eastern Cape.

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The adoption and challenges of electronic voting technologies within the South African context

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Abstract

This study explores the adoption and challenges of electronic voting technologies within the South African context with the aim of understanding how South Africa can leverage on the opportunities of electronic voting technologies. The study was conducted by surveying a broad diversity of citizens in the Cape Town area and semi-structured interview with the Independent Electoral Commission officials. Efforts to understand the current electoral system and its challenges are made and factors that could influence the adoption of electronic voting technology discussed. The analysis is based on thematic analysis and also Rogers' diffusion of innovations theory framework. The findings indicate that Relative advantage, Compatibility, Complexity, Trust in the innovation and the availability of infrastructure and resources are important factors that could influence the adoption of electronic voting technologies. This study is only based on a survey done in Cape Town and the findings may lead to further research on a large sample of South African citizens.

Keywords: *Electronic voting technology, Diffusion of Innovation (DoI), E-democracy, E-governance.*

1. Introduction

The technological development in South Africa has opened up the possibilities of the use of ICTs in the democratic and governance process. E-democracy has been defined as a tool for abandoning the representative system for one with more direct citizen engagement [1]. However, Garson has different view of what e-democracy is, he sees e-democracy as an umbrella term that covers many democratic activities carried out through electronic means and broadly defines e-democracy as "the use of ICT by governments to improve the efficiency, equity, and quality of democratic participation."[2]The major applications of e-democracy include mechanisms to inform, consult, and broadly engage citizens through ICT use in the political process. These mechanisms are usually called "e-participation" or "e-engagement". Clift states that "e-democracy builds on e-governance and focuses on the actions and innovations enabled by ICTs combined with higher level of democratic motivation and intent." [3] Governance according to Lai and Haleem is the system of leading and controlling the actions, affairs, policies and functions of a political unit, organization or nation [4]. E-governance or electronic governance is using ICTs at various levels of the government and the public sector and beyond for the purpose of enhancing governance [5] - [7].

E-participation has been defined as the use of ICT supported platforms to facilitate the participation in the democracy and governance [8]. Voting forms an important part of democracy and for any country to be able to sustain democracy, voter participation is a key consideration. Rosenstone and Hansen argued that elections represent an important field to measure the ICT political use because of voting as the main participation channel [9]. Electronic voting (also known as e-voting) is a term encompassing several different types of voting, embracing both electronic means of casting a vote and electronic means of counting votes. According to the ACE Electoral knowledge Network, countries like the USA, Brazil, and

India have successfully implemented e-voting to address various challenges associated with the manual paper based electoral process [10]. This study analyses the challenges and prospects of adopting an e-voting system and how South Africa can leverage the opportunities it presents. The study also looks at the factors that could influence the adoption of electronic voting This study looks at e-voting technologies against the manual paper based voting systems and does not look at a specific voting technology.

2. Background information

The constitution guarantees democracy in South Africa; every citizen over the age 18 has the right to vote [11]. South Africa held its first democratic election in 1994 and was run by the Independent Electoral Commission (IEC) and also included international observers who declared the electoral process free and fair. The IEC is a permanent body that was established in-terms of the Electoral Commission Act of 1996. It is independent from government but reports to parliament. The IEC has been responsible for implementation of the electoral system for the elections in South Africa since the first democratic elections. A possible drawback to the current electoral system according to the SouthAfrica.info is the number of illiterate adults in South Africa [12]. Another contributing drawback to the current electoral system is the level of poverty in South Africa. According to World Bank report South Africa 2009, 50% of South Africa's population still lived in under privileged conditions [13]. Transport from rural areas to polling stations can decrease voting registration and participation. People may not have the necessary funds to travel to an election polling station, which can be the reason for voter turnout decreasing in the South African elections. According to Kersting in 1994, 84% of eligible voters cast their vote. In the 1999 election that figure declined to 63% and in 2004, the election had a 61% turnout [14].

As per the Electoral Institute of South Africa report no. 12 2009, the cost of the physical ballot paper is also identified as drawback of the current paper based electoral system [15]. Another concern is confidence in the ballot form. According to a survey done by Citizen Surveys in October and November 2008, South African citizens were concerned that the secrecy of their ballot forms could be compromised. A sample was conducted on 2400 South Africans revealing that 58% had confidence in the secrecy of their ballots forms. In a report delivered by the Electoral Institute of South Africa, the 2009 elections showed that a large number of election officials did not have a clear understanding of the counting process which led to delays. They observed that some of the polling stations used one ballot box for both the national assembly and provincial legislatures. Also the seals on some ballot boxes were not applied using the correct procedures [15]. Based on the background information it is clear that the current paper-based electoral process can be significantly improved to mitigate some of the challenges it is faced with. This study proposes that the adoption of electronic voting could perhaps drastically reduce some of these problems and in the process improving the electoral process. Some countries around the world are successfully implementing electronic voting systems to address many challenges associated with costs of physical ballot paper and other overheads, electoral delays, distribution of electoral materials, and general lack of confidence in the electoral process. South Africa however, has not leveraged the opportunities that e-voting presents. Manual voting is often tedious, non-secure, and time consuming, which leads us to think about using electronic facilities to make the process more efficient.

3. E-governance in South Africa

The South African government has launched a number of e-governance initiatives since its inception in 1994. These initiatives are outlined in a project dubbed information communication year 2005. Kroukamp, lists some of the basic steps taken, including the installation of public information terminals for Internet and email access in certain rural centres as part of the joint public/private sector initiatives and the funding of computer centres in rural communities by companies such as Microsoft [16]. Some of these initiatives include South African Revenue Services (SARS) e-filing to facilitate the electronic submission of tax returns, the National Automated Archival Information Retrieval System (NAAIRS), provides extensive information and documentation about the national archive services to the public and to governments bodies. The Department of Home Affairs' National Identification System (HANIS) project, which has initiated an automated identification of database of fingerprints to combat crime and supply information for the purposes of policing. [16] According to Booz Allen

Hamilton, when e-governance is used to its full potential, it can provide the convenience of electronic voting and encourages e-participation in public forums by all citizens [17].

4. Electronic voting technologies

Participation is commonly understood as joining in, either in the sense of taking part in some communal discussion or activity, or in the sense of taking some role in decision making. E-participation as defined in the introduction section (1) can take place within the formal political process e.g. voting, or outside it e.g. political activism [18].

Smith and Macintosh are of the view that a modern e-enabled system of democratic governance seems to require some sort of modernisation of the voting process, whether through e-counting methods or an e-voting system [19]. According to Macintosh the most powerful symbol of a democracy is the involvement of the citizens in the free and fair elections of representations to govern them [20]. Macintosh continues to argue that voting is seen as the act that currently defines the relationships between citizens, governments and democracy. As such e-voting takes on a powerful symbolic role in e-democracy. According to Qadah and Taha, the term electronic voting refers to the use of computers or computerized equipment to cast votes in an election [21]. They continue to state that "e-voting aims at increasing participation, lowering the costs of running elections and improving the accuracy of the results." According to Sæbø, Rose and Skiftenes Flak electronic voting is an activity within the e-participation field where e-participation actors (citizens, politicians, government institutions, voluntary organisations) conduct such an activity in the context of some factors (information availability, infrastructure, underlying technologies accessibility, etc.) which then result to certain effects like civic engagement, deliberative and democratic [22].

Electronic voting and counting technologies are increasingly being used around the world with India and Brazil taking the centre stage. Belgium and the Philippines also use electronic voting and counting technologies for their national elections. Countries such as Estonia, Norway, Pakistan, and United States are at various stages of piloting partially using electronic voting and counting technologies, including the use of internet voting. Brazil and India have successfully implemented e-voting to address various challenges associated with the manual paper based electoral process. There are various factors that could drive one nation towards an electronic voting or counting technologies which may not be present for another nation, or may indicate a different solution. For example the challenges of moving paper ballots around large countries like Russia and Kazakhstan make the use of electronic voting technologies potentially beneficial on logistic grounds. The existence of a smart ID card with digital signature for the majority of the population in Estonia makes the use of Internet voting more feasible in Estonia. The Philippines adopted an electronic counting solution to deal with issues related to fraud during the counting process. Factors that argue for or against the use of electronic voting or counting technologies in a particular country are specific to that country and will have many different sources – legal, cultural, political, logistical, environmental etc. Technological developments in South Africa have opened up the possibility of e-voting technologies and this clearly provides some opportunities and challenges. Svensson and Leenes argue that on the one hand, the electronic voting technology may help to make voting more cost effective and more convenient for the voters and may even increase voter turnout. However on the other hand, e-voting may introduce new risks and affect the electoral values such as secrecy of the vote and placing of voting as an observable institution in modern democracies [23].

5. Adoption Model

This study adopts Rogers' diffusion of innovation model as a theoretical framework [24]. Rogers defines diffusion as "the process by which an innovation is communicated through certain channels over time among the members of a social society". He further differentiates the adoption process from the diffusion process in that the diffusion process occurs within society, as a group process; whereas, the adoption process pertains to an individual. Rogers defines the adoption process as "the mental process through which an individual passes from first hearing an innovation to finally adopting the innovation [24]. Diffusion theories are about the dynamic of change, in diffusion model the differences between or within a society are no more than a starting point. Diffusion models are not concerned with whether an innovation has been adopted but when it is or will be adopted [25]. Based on Lee et al. the diffusion of Innovation (DoI) model has emphasised that the attributes of new technology as key determinants of adoption [26]. This is one of the reasons the framework was chosen for this study. DoI theory according to Rogers seeks to explain the process and factors that influence the adoption of new innovations; this is in line with the objective of this study which is to explore the factors and challenges that could influence the adoption of electronic voting technology within the South African context. The study uses three constructs from the DoI framework, Relative Advantage, Complexity and Compatibility. These three innovation characteristics had the most consistent significant relationships to innovation adoption. According to Rogers individuals' perception of the attributes of an innovation and not the attributes as classified objectively by experts or change agents, affect the rate of adoption [24]. Rogers defines these attributes as follows: *Relative advantage* as "the degree to which an innovation is perceived as better than the idea it supersedes". *Complexity*, which is comparable to Technology Acceptance Model's perceived ease of use construct, "as the degree to which an innovation is perceived by the potential adopter as being relatively difficult to use and understand" and *Compatibility* as "the degree to which an innovation is perceived to be compatible with existing values, beliefs, experiences and needs of potential adopters." [24] Relative advantage was relevant for this research as the study wants to know how the voters in South Africa and the IEC officials compare the new technology (e-voting) to the current paper-based electoral process. For example the relative advantage will examine the research participants' point of view and the reasons they would be in favour or against electronic voting technologies. According to Taylor and Todd, compatibility is an important construct that can positively influence adoption [27]. They give an example stating that "if the use of an innovation violates a cultural or social norm it is less likely to be adopted" [27]. Complexity "is equivalent to ease of use (PEOU is the direct antonym of complexity)" [28]-[30]. An example could be; finding out if voters perceive electronic voting to be easy to use or not, is similar to finding out if electronic voting could be complex to use or not; therefore the researcher has assumed it is the same.

6. Research Methodology

This research is an exploratory qualitative study with an interpretivist approach. Interpretivism is based on the observation that there are major differences between the natural world and the social world. Interpretivist researchers thus attempt to understand a phenomenon through accessing the meanings assigned to them by participants. The aim of interpretivism is to understand the individual experiences of those being studied, how they think and feel and how they act/re-act in their habitual contexts. According to Walsham the purpose of interpretivist approach in Information System is to produce an understanding of the context [31].

The sampling unit are eligible South African voters and the Independent Electoral Commission of South Africa in the Western Cape. The study used an online survey questionnaire which was designed in-line with guidelines for questionnaire design recommended by Babbie and Mouton [32]. The questionnaire contained both open-ended and closed-ended questions and evolved around participants' view of e-voting technologies in general in comparison with the manual paper based voting systems currently used. The questions asked were clear and simple to avoid double meanings. The questionnaire was then pre-tested with a small group of people before it was administered to the study population. This was done to see if the respondents were able to understand the questions and also to identify which questions the respondents were reluctant to answer [33]. Those involved in the pre-test were no longer eligible for inclusion in the final survey sample [34]. Appropriate revision of the questions was made and the final draft of the questionnaire was administered for the study. A link to the survey was then sent to participants via email. This study utilised purposive sampling which is a type of nonprobability sampling to obtain participants for this study. Purposive sampling involved the researcher making a conscious decision about which individuals would best provide the desired information required for this study [35-36]. there is also a snowballing effect taking place as the participants invited others to the survey. A total of 400 participants agreed to take part in the survey; owing to time constraints a larger sample size could not be obtained. Out of the initial 400 invites sent out only 245 responses were received (a 60% response rate). Out of the 245 responses only 180 were admissible meaning all the questions were answered as required. The other 65 respondents either exited the survey half way or did not attempt to answer some of the questions. An in-depth semi-structured interview was conducted with officials from the IEC who oversee the running of elections in South Africa. The semi-structured interview included questions about the electoral process, challenges with the current electoral process and how the deal with those challenges, the IECs' knowledge of electronic voting and counting technologies, South Africa's readiness for an e-voting or counting system and what factors the IEC thought could hinder the adoption of any of this systems.

This study used thematic data analysis for analysing the data; Braun and Clarke define thematic analysis as a qualitative analytic method for "identifying, analysing and reporting patterns (themes) within data [37]. It minimally organises and describes your data set in rich detail. However, frequently it goes further than this and interprets various aspects of the research topic". In general thematic analysis involves the searching across a data set to find repeated patterns of meaning [38]. Furthermore according to Fereday and Muir-Cochrane, thematic analysis is a form of pattern recognition within the data, where emerging themes become the categories for analysis [39]. After going through several literature on analytical techniques, the study chose to use thematic analysis because of some of the advantages it presents; "Can carefully summarise Key features of a large body of data and offer a thick description of the data set" and "can highlight similarities and difference across the data set" [38]. The DoI framework was also used as a theoretical lens for analysis to validate the analysis process. The themes that emerged from the data were categorised based on the theoretical constructs which are relative advantage, compatibility, and complexity.

7. Results/ findings

Figure 1 represents the percentage of findings from the closed-ended questions from the survey. The questions represent a comparison between electronic voting technologies and the manual paper based system currently used.

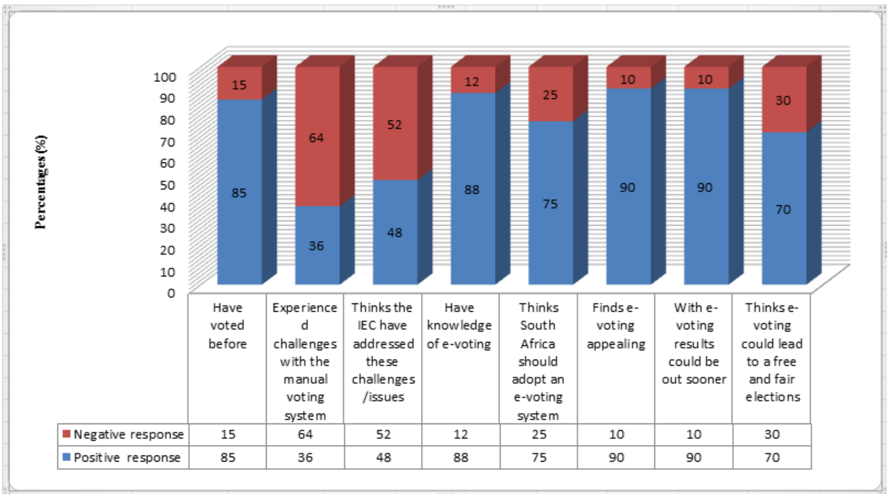

Figure 1 (Percentage of Responses comparing e-voting and Manual paper based voting)

The findings from the open-ended questions were analysed and then categorised into themes. One of the themes to emerge from the survey data was the *perception of the technology*; it is derived from the category of convenience and accessibility and several other sub-categories. The summarised sub-categories revealed the general voters' perception of electronic voting technology. Statements from some of the responses included the following: "…e-voting technologies would make voting fast and easy therefore reducing the long queues at polling stations." and "…e-voting technology will reduce the amount of money used for running the elections because there will be no printing of paper ballots etc." This theme fits well within the relative advantages construct context. Based on the findings the participants perceive that an electronic voting system could be better than the current paper based electoral system. *Attitude towards technology* is another theme that emerged from the survey data. According to Rogers attitude towards an innovation is a critical intervening variable in the innovation adoption decision, thus attitude towards a specific information technology (in this case electronic voting technology) is conceptualised as a potential user's assessment of the desirability of using that technology [23]. Based on the responses from the survey, those who had positive perception of electronic voting technology had a positive attitude towards it. Some of the responses included "…with e-voting voters would be able to vote from anywhere no matter what their geographical location is." On the flip side there are those participants who had a negative attitude based on their perception that electronic voting would bring with it a lot of risks such as system hacking etc. The concept of compatibility in this study captures a citizen's perception of the similarity of e-voting with other technology innovation accessible to the participants. Responses from the participants suggest that voters who have used systems like SARS e-filling and online banking transactions are likely to view e-voting as consistent with the way they interact with other entities: people, organizations, and government. Asked if electronic voting would appeal to them compared to the current paper based electoral process, statement of some of the responses included the following: "…there are other electronic services that are offered in the country for example online banking, filling of taxes online etc. … I think e-voting would appeal to me coz it fits right with such services." The theme attitude towards technology also fits with the DoI construct compatibility. The attitude (negative or positive) that the participants have towards existing innovations could also affect their attitude towards an electronic voting system.

The findings from the interview with the IEC officials revealed several themes. These themes were then analysed to try and fit the themes into the predefined DoI constructs used in this study. Based on the findings the first theme to emerge was *perception of technology;* the IEC officials had the perception that an electronic voting system could be very useful especially when it came to the counting of votes. Asked if South Africa needed an electronic voting system to mitigate some of the challenges the current paper based system was facing, the following are some of the responses: "I think South Africa could use an electronic voting technology that could count the votes as soon as they are casted especially in the under resourced communities." The second theme is the *attitude towards technology;* this mainly comes from the perception of electronic voting by the IEC officials. Even though the IEC perceives the technology to be better than the current paper-based system especially when it comes to the counting of votes, they had a negative attitude towards it citing issues like trust and security risks that could emerge with the introduction of electronic voting technology. There is also the issue of their awareness of other countries that have abandoned the use of electronic voting systems and are back to using the paper based system or a combination of both systems because of the risks that e-voting presents. Some of the responses from the IEC interview include; "…we aware of the countries like the Netherlands and the UK who previously had e-voting systems but now are going back to the manual based system or a combination of both systems… we must first look at the reason this countries are backtracking on e-voting before we think of adopting it." The construct compatibility was looked at from an angle of how the IEC perceived electronic voting technology to be compatible with theirs and the voters' needs, experience and existing values. Some of the responses from the interview include the following; the IEC states that "… we need a system that can count ballot papers as the votes are cast… " they are also of the view that IEC could use a system to help them run the elections smoothly especially in the under resourced communities. Based on these responses it can be said that the IEC perceive electronic voting technology to be consistent with their need to adopt it. From the findings of the interview the IECs' perception that electronic voting technology could be difficult to use and understand especially for the citizens in the informal settlements whose level of education is low. "… the level of literacy in the informal settlements is very low … some of these voters may find it difficult to use or such a system…"

Another theme from the interview is *infrastructure and resources*; the IEC officials are of the view that even though it would be a good system to have the lack of proper infrastructure and low resources to support the implementation of the system especially in the informal settlements and rural communities will make adopting this technology difficult.

In general the findings reveal that the overall perception of the voters is that e-voting could possibly be a much better system than the current manual paper based system. Voters are of the view that e-voting could make the way in which they cast their votes much easier. The IEC on the other side is of the view that although e-voting as a good system, they also think that the risks and challenges of adopting and implementing such a technology are high. The IEC is also of the view that several factors and have to be considered before e-voting can be adopted in South Africa.

8. Discussion and conclusion

This study identifies from the findings various factors that could influence the voters and the Independent Electoral Commission's intentions to adopt electronic voting technologies. The findings showed that the three DoI framework constructs relative advantage, complexity, and compatibility exert an important influence on the voters' and IECs' decision to adopt electronic voting technology. The factors that emerged from the findings included the following; Usefulness of the technology, Ease of use, Trust in the technology, resources and infrastructure, and environment.

Usefulness of e-voting technologies: the findings revealed that the participants favoured electronic voting technology over the current paper based system because of their perception of its usefulness which included convenience of access, time saving, cost (transportation) and the effort it would take to vote. They also favoured electronic voting because they perceived that this system would be able to reduce human error in the electoral process and also increase transparency in the elections. The participants also had the view that such a technology would prevent them from encountering nerve-wracking situations such waiting in long queues at voting stations, intimidation from party agents and many more. These findings confirm the results of the construct relative advantage. The findings from the survey data suggests that the adoption of electronic voting technology is likely possible if they perceive it to be better than the current paper- based system. The IEC also perceived the usefulness of e-voting in terms counting the votes. **Ease of use:** This factor can be compared with the DoI construct complexity. When a technology is perceived by potential adopters as being relatively difficult to use and understand. Based on the findings some participants thought electronic voting system would be difficult to use or understand especially amongst elderly citizens who have no knowledge of such a technology. There was also a concern from the IEC regarding the illiterate citizens in informal settlement who have not had prior use or experience of such technologies might find e-voting difficult to use.

Trust in the innovation: The findings show that trust in the technology is a likely factor that could influence the adoption of electronic voting. The participants thought security and privacy issues were factors that might prevent them from trusting and therefore adopting electronic voting technologies. Based on their knowledge or experience of other electronic systems that have been affected by security and privacy issue, these participants thought that if e-voting were not secure enough, their voting right could be under threat and their voting information altered or misused by hackers. **Resource and infrastructure**: The provision of resources and infrastructure to facilitate the introduction of any innovation is of importance and could influence the adoption of a technology in this case electronic voting. Increased resources would be needed to either provide additional staff training or funding to administer the new voting channel. The findings from the interview with the IEC revealed that the availability of ICTs infrastructure and resources especially in the informal settlements is a factor that could influence their decision where or not to adopt electronic voting. Lack of infrastructure and resources would hinder the adoption of e-voting. Finally the **Environment** factor, findings from the interview also revealed that the environment within which the potential innovation is to be introduced could influence the adoption of that technology. The interview data showed that before the IEC can decide on adopting an electronic voting technology, they should put into consideration the political environment and the citizens' environment as well. The extent to which both these environments accept the technology is crucial in the IECs' decision on whether to adopt electronic voting or not.

In conclusion the findings in this study revealed the importance of the three DoI constructs in the adoption and diffusion process of e-voting within the South African context. The study also reveals other factors that could influence the adoption of e-voting technologies like lack of ICT infrastructure and resources, trust in the technology, digital divide, and the environment from the perspective of both the voters and the Independent Electoral Commission officials. If South Africa is to consider the adoption of an e-voting system these factors have to be addressed first.

9. Limitations to the study

There are some aspects of this research that may limit the interpretation of the results. First, the data was collected solely based on a sample from the Cape Town population, which may not be representative of the South African population thus limiting the generalizability of the findings of this study. The study also focuses on the voters who have some kind access to computers and the internet. The study however gives insight into the factors that could possibly influence the adoption of electronic voting technology within a South African context.

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Framework for implementing ICT4D initiatives in Rural Communities of South Africa

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Abstract

South African rural communities have received Information and Communication Technologies services through initiatives such as Telecentres, Living Labs, Thusong centres and computer application donations in schools or other public spaces. Many people focus mainly on Information and Communication Technologies deployment, but with no standard plan in place to ensure ICT sustainability which might benefit rural communities. Therefore there is a need to establish a framework for implementing Information and Communication Technologies for development initiatives in order to ensure successful implementation of these initiatives in rural communities. Literature shows that a successful framework for rural communities should include Information and Communication Technologies stakeholders, Information and Communication Technologies policies, Information and Communication Technologies infrastructure, Information and Communication Technologies services, monitoring, evaluating, training and maintenance. This paper will present a framework for implementing Information and Communication Technologies for development initiatives in rural communities which will be developed using secondary data and existing frameworks from different countries and try to make it relevant to the rural community context in order to reduce the number of initiatives that are abandoned or which end up not serving their intended purpose in rural communities of South Africa.

Keywords: *Information and Communication Technologies, Information and Communication Technologies for development framework, development, rural community, implementation*

1. Introduction

ICT initiatives have been deployed across South Africa to respond to the call of improving lives of people living in rural areas, and also facilitating online access to government services [1]. This has been done through a number of interventions such as public libraries, Telecentres, Living Labs, and Thusong service centres. The definitions for the mentioned initiatives are as follows:

a) Telecentres: are defined as a public place providing connectivity and access to information through a range of information and communication technologies including phone, fax, computers and Internet [2].
b) Living Labs: are defined as systematic initiatives focusing on promoting open, user-driven innovation in rural ICT services and applications [3].
c) Thusong Service centres: are defined as hubs within a rural community which provides information and services in an integrated way [4].

Even though several ICT initiatives have been developed to make a positive change in rural people's lives, these still do not yield the expected results as they is faced with challenges that hamper their successful deployment in rural communities. Some of the challenges include poor infrastructure, insufficient training, financial constraints, low literacy levels, lack of access to markets and market information, as well as inappropriate economic policies [5, 6]. As an attempt to alleviate the mentioned challenges and barriers that affect the successful implementation of ICT in rural communities, this paper will investigate and propose a framework that can be use by all those who are interested in implementing ICT4D in rural communities. By definition implementation is a specific set of activities designed to put an activity or initiative into practice of known dimensions [7]. ICT project implementation is also

described as process of carrying out activities and tasks in accordance with planned actions, ensuring that the budget, time and quality dimensions are in balance and that the objectives are met [8]. In light of these definitions it is clear that when implementing ICT for development initiatives there are activities that need to be carried out by those responsible for the implementation; and there is a need for contribution from a number of participants to ensure presentation of various stakeholders.
This paper will start by providing a brief background on rural community context which will be discussed in the next section.

2. Understanding rural communities

The concept of a rural community has attracted a number of definitions and interpretations depending on whether a country is a developed or a developing country. In an attempt to define this concept, a meaning of term 'rural' will be defined followed by the meaning of the term 'community'. Rural refers to a sparsely populated area in which people farm or depend on natural resources, including village sand small towns that are dispersed throughout these areas [8]. Additionally, it has been highlighted that these areas experience lower income level and lesser job opportunities [9]. On the other hand the term 'community' has been defined as an interaction among individuals with shared identity for mutual support [10].

The combined definitions of the terms 'rural' and 'community' result in a description of rural community as a way of life for communities with limited transportation access (road, air, and rail); limited access to a commercial/service hub; limited infrastructure (water, off-grid). It has also been pointed out that rural communities are the bedrock of human development as they ensure transmission of language; and also economic base, culture values and practices, and social structure of rural communities are different for each community [11]. From the highlighted definitions, there is no doubt that rural communities are faced with a lot of challenges with respect to access to basic services within their communities as compared to people who reside in urban communities. These are discussed next.

2.1 Challenges facing rural communities

Rural communities experience many gaps and challenges in accessing basic services which are believed to be as a result of inconsistencies in funding levels meant for rural communities [12]. These challenges can be categorised as follows:

- **Social Challenges:** insufficient professional assistance for rural communities, inexistence of government structures, scarcity of resources to support teaching and learning in rural communities affect the rural teachers; inappropriate teaching methods used resulting in low levels of education [13]. Furthermore, rural people have to travel long distances to access basic health care services, as the healthcare systems do not support care givers to deliver health care at homes. Local and public health programs do not provide information on relevant health care support to rural people [41].
- **Economic challenges**: rural communities have poor or no access to connectivity infrastructure as providers of Internet services are located in urban areas, and as such these communities possess limited access of rural population to social and economic information. Social and economic services are poorly delivered from public and private sectors to local institutions, and there is lack of access to business opportunities and information services [15]. Lack of interest by partnering countries in rural issues, poor commitment and weak past performances in the banks by rural famers are some of the reasons that were mentioned to have a negative impact on the rural agricultural activities [16].
- **Infrastructure Challenges:** high cost of infrastructure results in implementation of poor and unreliable infrastructure in rural areas which exhibit problems associated with access to information needs and technological services [17].

At the forefront of challenges facing rural communities is the lack of access to relevant information which makes it hard for the rural people to access basic services. As the large number of people in developing countries live in the rural communities, it is clear that rural people are affected by the aforementioned challenges. The next section will briefly highlight the status of the rural communities in the Eastern Cape as this paper is focused on the rural communities within South African.

2.2 The status of rural communities in the Eastern Cape Province

Eastern Cape is a province situated along the coast of South Africa, with a population of approximately seven million, 16% representing the South Africa's population. This province is one of the poorest provinces in South Africa and the conditions of schools are a true reflection of inequalities between the relatively wealthy urban areas and rural areas. People in this province still survive below the poverty line as they still depend on firewood for energy and river for water. Agricultural activities are neglected; education, health, water as well sanitation infrastructure services are also inadequate [18].

The analysed status of the rural communities in the Eastern Cape and other rural areas attracted attention of various key role players in South Africa's development and economy such as government, NGOs, donors, public and private sectors and motivated them to set up programmes and provide funds to support rural development [19]. This has resulted in the establishment of initiatives serving as access points for all government services and information required by people in rural communities for socio economic development through the use of Information and Communication Technologies (ICTs) [20]. The ICTs concept will be addressed in the next section.

3. Information and Communication Technologies (ICTs) for socio-economic development

There is no doubt that ICTs have infiltrated all activities of human life and are now widely accepted to play an important role towards social and economic development. ICTs are defined as an expanding assembly of technologies that can be used to collect, store and share information between people using multiple devices and multiple media [21]. ICTs hold a great promise for the poor areas of the world as they can be used to enhance activities to improve standards of living as well as stimulate economic growth [22]. In an attempt to bridge the digital divide between the developed and developing countries, a field called ICT4D has emerged with the aim to accelerate the development wheel and extend it to the rural communities. ICT4D refers to the use of Information and Communication Technologies (ICTs), such as computers, the internet, mobile phones and traditional media such as radio, to advance human and social development [23].

There are many ways in which ICTs have been applied to support the above statements; these are shown through the examples of the ICT initiatives that have been implemented world-wide. The following section presents benefits and challenges that can be achieved through deployment of ICTs in rural communities.

3.1 Benefits of using ICTs for rural development

View points on the benefits of using ICTs for rural development are grouped into three categories which are: social, economic and political [24].

- **Social benefits of using ICTs for rural development:** Communication and access to information are some of the benefits of introduction of ICTs in rural communities. This also involves online access to press in digital formats, authored information sources, educational and research purposes as well as accessing local government services and information [25]. Internet also enhances the delivery of education outputs through the use of e-learning which is said to have potential to bridge the educational gaps experienced by rural communities. Doctors in a rural community can be able to access up-to-date information on outbreak of diseases and be able to treat and warn the rural community in advance [24].

- **Economic benefits of using ICTs for rural development:** Rural people can experience economic benefits through the use of ICTs and the most important benefit comes with the use of Internet which has made lives more economical, as it saves time of travelling and money [26].

- **Political benefits of using ICTs for rural development:** ICTs can be used to assist rural people to engage in democratic processes through the use of web-based public information kiosks, electronic citizens' forums and electronic voting. Political parties can make use of social networking forums to stay in touch with their wards [27]. E-Government applications can be used to enhance free and fair elections, transparency of electoral processes, and increase efficiency of voters' registration and polling processes [28].

3.2 ICT challenges in rural communities of the Eastern Cape Province

The status of the rural communities in the Eastern Cape Province fits directly to the definitions of rural community and the highlighted challenges are also a case in this province. A number of challenges that are specific to this province in respect to adopting ICTs in its rural communities were found as follows:

- Connectivity in rural communities is sparse as there are challenges with wireless and cables infrastructure that still needs to be addressed
- ICT skills drain is great challenge for Eastern Cape as students and graduates are attracted to other provinces for better work opportunities
- Government structures work in silos resulting in threatened seamless user experience
- Public entities' lack of cooperation results in lack of coordinated effort and general acceptance of the ICT strategy [29].

Implementing ICT initiatives in a rural context becomes a challenging and complex activity as these initiatives become unique responding to the rural environments that they are in, like in the case of the mentioned challenges in the Eastern Cape Province. This results in many issues that need to be considered which will be unpacked below.

4. Implementing ICTs for development initiatives in rural communities

Advancements in ICTs play a vital role in dissemination of knowledge and information to rural communities [30]. The implementation of these ICTs in rural communities requires an exclusive understanding of underlying issues that will assist in making the ICTs initiatives to become responsive to the rural environments in which they are being implemented. These issues are shown in the figure below:

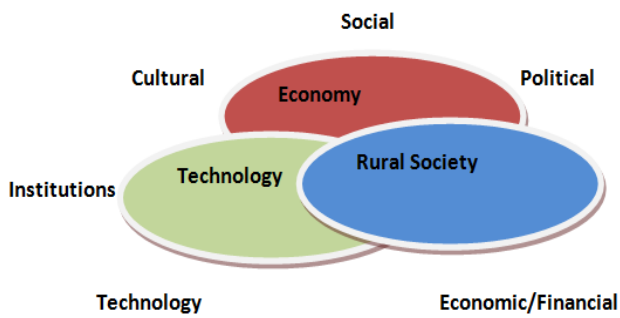

Figure 1: Issues to be considered when implementing ICT4D initiatives in rural communities: Pade, Mallison, and Sewry [6]

In this diagram the following issues were highlighted:

- **Economic issues**: problems related to the production, management and use of resources for rural development to meet the communities' needs.
- **Technological issues**: refer to the choice of technology for rural environment which should support specific ICT initiatives and consider factors that may negatively influence its implementation.
- **Rural Society issues**: include social, cultural and political issues that shape a rural community [9].

Strategic planning was highlighted to be the most critical feasible factor amongst the discovered list of feasibility factors [10,11]. This means that these issues are of importance when implementing ICTs in rural communities.

A number of ICT4D initiatives tend to be focused more on the technological issues ignoring the non-technical issues thus resulting in negative implementation of these initiatives in rural communities [9]. Also, consideration of factors like the rural community context and community participation is important towards successful implementation of ICTs in rural communities. The revealed issues and challenges set premises for this paper to propose a framework that can be used for implementing ICTs for development initiatives in rural communities. The following section will then provide results from literature review on existing studies and frameworks for implementing ICT4D initiatives in rural communities.

5. Factors to consider for implementing successful ICT for development initiatives in rural communities

A successful framework for rural communities should include consideration of ICT stakeholders, ICT policies, ICT infrastructure, ICT services, monitoring and evaluation, training and maintenance [12, 13]. Current literature confirms that these factors form components of a successful framework for implementing ICT initiatives in rural communities which will be discussed below [8, 17].

a) **ICT4D Stakeholders**

ICT planning needs establishment of appropriate governance arrangements in a form of management structures that will assist to ensure that the ICT activities are in line with government policies and priorities as well as the objectives of the ICT initiatives [15, 9]. For ICT4D initiatives, an ICT4D steering committee is an appropriate management structure that can be set up to ensure that ICT4D activities are carried out effectively.

ICT4D steering committee is defined as a key body that is organized to ensure that ICT strategies that are practised by an ICT4D initiative are aligned with its strategic and corporate objectives [12]. The role of the ICT4D steering committee is to ensure that the ICT resources are used and managed effectively and that the initiative is implemented according to the objectives that are outlined in the development plan and ICT policies. ICT4D steering committee stakeholders should include rural community champions, rural community members with basic computer literacy, project initiators, donors, as well as local and national government representatives. The inclusion of the rural people in ICT4D management structure will make them to as feel part of the initiative and thereby creating sense of ownership, rather than seeing the initiative as being owned by the project initiators [16].

After setting up the ICT4D steering committee, the stakeholders need to work together in carrying out the following activities:

b) **Financial sources and stability**

For any initiative to be implemented successfully there need to be finances in place to support the development and operations of that initiative. Therefore before deciding on implementing ICT4D initiative; funding plans should be determined as they will be the deciding factor on whether the initiative will be successfully implemented [30]. Once the funding and finances are in order, it will be easy to decide whether to go on with the ICT4D implementation process. Implementation of ICTs in rural communities begins by identifying rural community needs that can be addressed by making use of technology. Highlighted next is a brief explanation on the importance of recognising the rural community needs and its value to the success of the initiative.

c) Consideration of rural community needs

Needs assessment is the fundamental component of implementing effective services and achievement of the objectives that can be defined as a process of getting involved in a community with the aim to assist community members to learn more about their current situation, problems and needs to facilitate development goals to address those problems [18, 20]. Prior to conducting a needs assessment, a baseline study should be carried out as part of needs assessment exercise as it will assist to guide the entire exercise by highlighting all the key needs and priorities of the rural community. It is recommended to engage community stakeholders as it is an effective way to learn more about the community and the services needed from the community members. Needs assessment will also help to determine if there are any existing infrastructures and services which can be used when implementing the ICT4D initiatives or if there will be a need and possibility to provide relevant infrastructure and services [19].

The technology infrastructure for an ICT4D initiative depends on the type of services required by the rural community. Affordable technology choices for a rural community set up may include: thin client systems, Linux operating system, Linux Terminal Server Project System, refurbished computers and handheld computers. As some of the rural communities needs may include electricity infrastructures affordable power sources can be established by making use of a solar power photovoltaic, wind energy, micro hydro-power clockwork power and surge protection [21, 12].

ICT services are defined as services that are offered to the user by the telecommunications network operator [20, 21]. For a rural community set up, these services should be established in consideration of the rural social context as they should be created to address specific rural community needs as outlined in the needs assessment. As rural communities are described to have challenges with electricity, finances, literacy levels and poor infrastructure; ICT4D initiatives should offer services that are demand driven as requested by the beneficiary, and these should be made to adapt to rural communities environments [21]. Computing services, communication services, training and education services, basic office services and information services are examples of services that should be offered to rural communities.
The two models on which ICT service provision in rural communities is based were discovered to be:

- **Private service access**: in this model the users own the ICT terminal devices which they use to access services from [20].
- **Communal service access**: in this type of a model the third party facilities provider (Telecentres, phone shop) provides physical premises for a shared use of ICT devices and services [20].

The difference between the above mentioned rural ICT services models is that it costs more to access services privately than accessing them from a shared or communal facilities provider. Therefore, the best model for accessing ICT services for a rural community is the communal service access model as it offers affordable access to ICT services, and some of the services that can be obtained from this model include public libraries, Telecentres, Living Labs and Thusong service centres. The rural ICT services should be implemented in such a manner that they are able to integrate the local content needs as identified in the rural community needs assessment.

d) **Continuous engagement with the community**

As mentioned earlier, regular communication and coordination amongst the stakeholders of an ICT4D initiative is central to the success of that particular initiative. Therefore ICT4D stakeholders should commit themselves to the sustainability of the initiative by maintaining effective communication channels that will require constant input and feedback from all stakeholders [31]. Marketing strategies can be used as a way of launching ICT4D initiatives to the community, because not all rural community members may be aware of the initiatives as well as products and services that are being offered by the initiative within their community. The relevant rural marketing strategies may include: word of mouth, rural community forums, community radio stations and Imbizos. Once the rural community is aware of these ICT4D initiatives they may use the ICT4D services offered by the initiative for their benefit [32]. The use of these initiatives needs to be evaluated and monitored in order to determine whether they are used effectively.

e) Human Resources

When the ICT4D initiative is up and running there has to be people hired to operate the initiative. Hiring rural community champions will also assist in making the ICT4D initiative effective as they will develop a sense of ownership as the rural community would want to see the initiative operational at all times. Additionally, training is also as important to equip the ICT4D users and the rural community with relevant skills to operate the initiatives. Human resources can also act an entrance for incentives for the people hired within the ICT4D initiative

f) **Development of evaluation, monitoring and feedback mechanisms for ICT4D initiative adjustments and sustainability**

Evaluation and motoring is a research based set of questions, interpretation and judgement of data from a forward-looking perspective on development priorities, mainstreaming and scaling to inform donors and partners. This exercise may include evaluation of resources, activities, participation, reactions, knowledge, attitudes, skills and aspirations, practices and evaluation of social economic and environmental conditions; which can be done through field notes, photography and video and audio recording [22, 1013 Different feedback mechanisms can be engaged as a means to establish regular communication among the stakeholders as the stakeholders will be informed of the status of the implemented ICT4D initiative; these may include but not limited to face to face communication, emails, chats, telephone conversations and SMS [31].

The above mentioned components are referred to as the best practice for implementing successful ICT4D frameworks [23]. These were also labelled as critical components for successful implementation of ICT4D in rural communities [24, 25]. Therefore, the review from the existing literature and the existing ICT4D frameworks enabled the development of the proposed framework as shown in figure 3.4 below. As this paper presents a proposed framework, hence there are no results to evaluate.

5.1 Presenting the proposed framework for Implementing ICT for development initiatives in rural communities

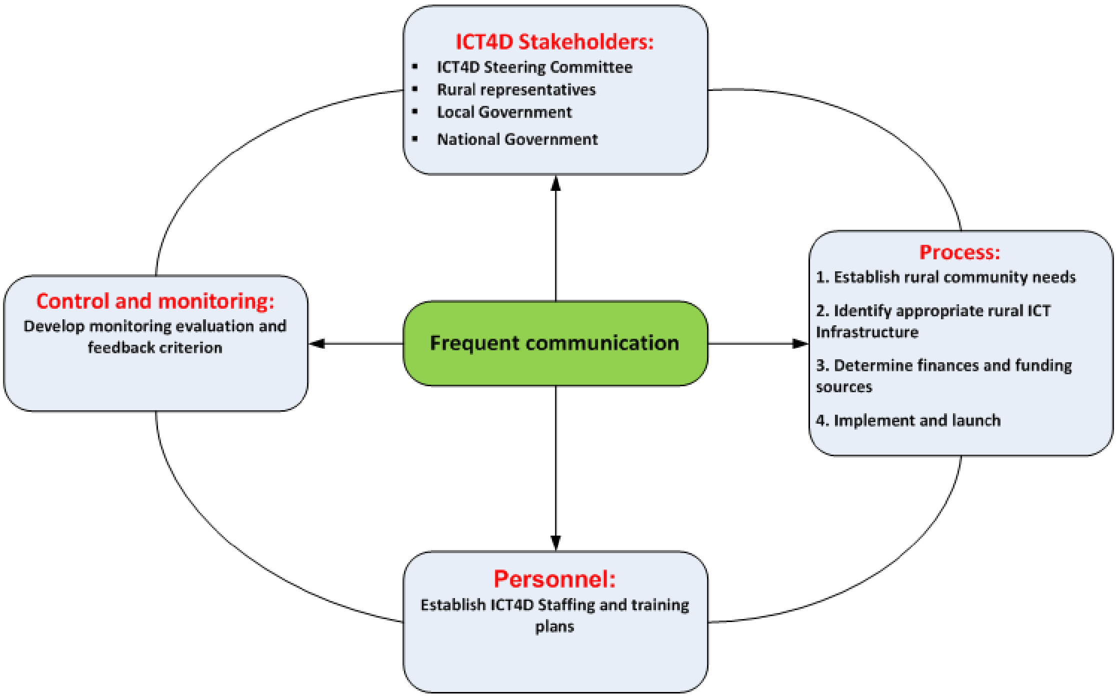

Figure 2: Proposed framework for implementing ICT4D initiatives in rural communities

The recommendation made by this paper is on the importance of coordination between the ICT4D steering committee, of which its stakeholders should also involve community members so as to create a sense of ownership and user involvement in the implementation of ICT4D initiatives. This will result in effective and successful implementation of ICT4D initiatives.

6. Methodology

Desktop research was conducted from extensive literature review on existing frameworks from different countries on how they manage to successfully implement their ICT4D initiatives. Most sources consulted are from journal publications and conference proceedings in the area of ICT4D. The data collected from the literature was used as a basis to develop the framework proposed in this paper.

7. Conclusion

Successful implementation of ICT4D initiatives is a task that involves multiple stakeholders. This makes it difficult to manage such initiatives as responsibilities are scattered amongst people with different social background. Continuous communication and coordination amongst stakeholders is emphasised in this paper, as this is one of the success factors in achieving the goals and objectives of the initiative. This framework will help to guide those interested in implementing successful ICT4D initiatives in rural communities. At this point in time the framework has not been evaluated, but it is believed that it will help to support the ICT stakeholders to implement successful ICT4D initiatives in rural communities.

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Presenter: This paper is presented by Gcotyelwa Phingilili

Factors influencing the use of system development methodologies when developing community information systems in living labs

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Abstract

The focus of Information and communication technology for development initiatives have changes from ensuring access to Information and communication technologies for disadvantaged communities to addressing specific needs of communities through Community information systems. These Community information systems have to be developed due to complexity of communities as compared to organisations and also lack of ready off-the-shelf systems addressing specific community needs. There is insufficient evidence on the use of system development methodologies (SDMs) when developing community based systems. This paper investigates factors influencing the use of SDMs during the development of community based systems in disadvantaged communities. Qualitative case studies have been conducted from three living labs around South Africa and the data was analysed using Atlas.ti.

Keywords: *Information and Communication Technology for Development, Community Information Systems, System Development Methodologies, Technology-Organisation-Environment framework, Contingency approach.*

1. Introduction

Information and Communication Technologies for Development (ICT4D) initiatives have evolved over time. Initially the main focus was closing the digital divide through ensuring access to basic Information and Communication Technologies (ICTs) [**1**,**2**,**3**] and this era is termed ‘ICT4D 1.0’ by [**4**] as it marked the massive rollout of telecentres to underdeveloped communities. This era experienced massive implementation setbacks as the focus turned to be on taking computers to people with little focus on how computers can be used towards improved living standards. The current era is termed ‘ICT4D 2.1’presents a shift from a supply- driven focus to a more demand- driven, where the community recipients are actively involved [**4**]. Using technology towards meeting the tailored needs of the poor communities is the focus of this new era. There has been remarkable recognition of the importance of developing systems that address specific needs of disadvantaged communities; Education, Health, Commerce, Government and Agriculture are amongst disadvantaged community needs that could be addressed by these systems.

A number of community information systems (CIS) have been developed to address the community challenges. CIS is the umbrella term that refers to ICT applications implemented to address the social, economic, political or cultural goals of a community [**5**]. These CIS are designed and build for use by memembers of a community to support a host of different social, economic and cultural goals [**6**]. Due to the complex nature of community and their environment, developing systems from scratch is necessary as it would be difficult to obtain an off-the-shelf community information systems. This means that systems have to be developed individually as an experiment for successive systems [**7**]. The dilemma facing information systems developers is creating a system that responds to community needs, and is fit for use by the users [**8**]. There is currently no evidence of use of System Development Methodologies when developing community information systems aimed at socio- economic development. This is not in line with practise in system development where it is believed that software methodology rules must be based on underlying domain [**9**]. As developers of CISs living labs are confronted with the responsibility of ensuring that the chosen system development methodology takes into account the various dynamics of a particular community. The question addressed in this study is: what factors influence the decision to use a system development methodology when developing CIS in living labs.

This paper identifies factors that influence the use and effectiveness of system development methodologies when developing ICT4D community information systems. A case study from three South African Living labs was conducted. These factors are presented using the Technology-Organisation-Environment (TOE).

This paper first presents a background onto CIS and then dynamics of system development methodologies are outlined. Then, the factors are identified and a framework is presented.

2. Addressing Community Needs through CIS

The definition of a community is no longer limited to people belonging to the same geographical location [**5**]; with new definitions people could be worlds apart but still be part of one community. Beyond physical location, communities are also differentiated by common values and interests [**10**]. Proliferation of internet technologies has also led to an even wider definition of a community where electronic media is used to communicate, commonly known as virtual community. Virtual communities are becoming even larger due to the popularity of Social Networks and the growing mobile phone industry, which makes it possible for people in the most disadvantaged communities to have interactions with the people from any class.
The adapted definition of ‘a community’ for this study is: “a *group of people facing similar socio-economic challenges, with ongoing interactions and common interests”*.

ICT initiatives provide resources and tools that serve individuals and communities by delivering access and empowerment in areas such as local economic development, cultural affairs, civic activism and community based health and environmental initiatives [**11**,**12**]. CISs play an important role in providing information needs of the community, and provide solutions to general (community notices, crime fighting, indigenous knowledge and risk management information) social (health, education, social services and access to government) and commercial (agriculture and entrepreneurial) needs of the community.

2.1 Using the Living Labs approach to Address Community Needs

South Africa has implemented a number of ICT4D initiatives with community specific systems. Living labs around the country offer potential in terms of systems developed with the needs of the community in mind. The living labs approach to ICT4D is aimed at facilitating innovation by early involvement of the users and experimentation in real world setting to bring upon community innovation [**13**,**14**]. Unlike the telecentres which had few stakeholders, living labs benefits from the variety of stakeholders and partners who are committed to innovation. The multi-stakeholder technique is instrumental in ensuring that development initiatives are not only aimed at meeting the needs of one party, but are inclusive enough to take into account the needs of various parties involved. Involvement of multi-stakeholders also brings hope that disadvantaged communities will indeed be the core beneficiaries of these initiatives. This is possible because living labs draw on the notion of external ideas as a resource to support innovation processes that lead to usable community products and services .

Each living lab is managed differently and serves or addresses the needs of a different community [**16**]. Some of the living labs have already developed a community system/s whereas some are still planning to introduce the systems. Systems that have been developed through living labs include enterprise based, logistics, agricultural and health based systems for communities. Some systems developed are aimed at ensuring the effectiveness and efficiency of processes and accountability amongst the involved stakeholders [**15**].

3. Developing CIS aimed at socio-economic development

Information System Development is a way of conceiving, analysing, designing and implementing information systems [**17**]. A working system is the desirable product of any system development project. With ICT4D, the challenge is that the need for a particular CIS is usually initiated by someone who is outside the particular community in need.

The need for specific methodologies for developing community systems arises from the differences in nature between organisations and communities. By their nature, communities are more complex than structured organisations. Organisations have well formulated policies, defined boundaries, usually with a single role of maximising shareholders' wealth whereas for making profit is usually not the initial focus when developing CIS. The social dynamics of disadvantaged communities cover a far wider spectrum compared to the limited structured social interaction found in organisations [**18**]. Poor information systems literacy, as identified above, means that the system developers would have to spend more time training users on using computers and also explain the system at length to the community users [**7**].

4. Theoretical background

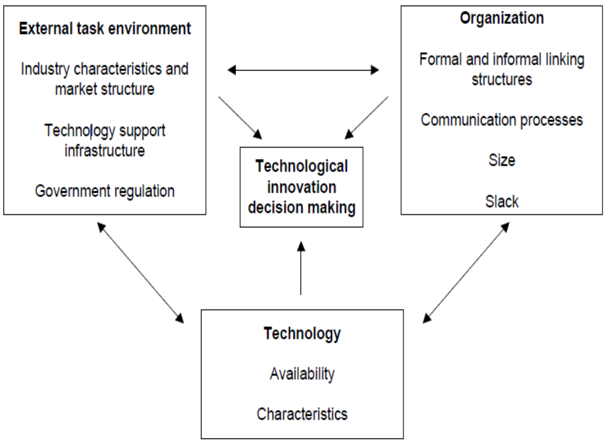

Figure 1: Technology-Organisation-Environment framework **[**19**]**

Technology-Organisation-Environment framework comprises three elements; technology context, organisational context and external environment. According to Information Systems research [**20**,**21**,**22**] the TOE framework has been widely used for adoption, assimilation and diffusion of technology and technological practices in organisations. This is due to the holistic approach that this framework presents in assessing the various elements affecting adoption. The TOE framework has solid theoratical basis and consistent emperical support in presenting both constraints and opportunities for technological innovation [**23**].

5. Research Methodology

An interpretive paradigm has been chosen for this study. This was conducted through qualitative multiple case studies. The case study is a widely accepted research method in information systems [**9**,**24**,**25**]. In a case study the research subjects are investigated in order to reach a particular conclusion about the enquiry. A case study is defined as an empirical enquiry investigating a contemporary phenomenon within a real life context when the boundaries between the phenomenon and the real life context are not clearly evident [**29**]. The benefit of a case study is the ability to examine data within a context specified by the researcher. The main purpose is not to generate general laws, but to understand phenomena in their context [**24**,**27**].

In selecting the case studies, two conditions were to be met. The first condition was that to be part of the study, the initiative should be a Living lab. There are several ICT based community initiatives aimed at using ICT4D towards improving the living standards of people from disadvantaged communities. These initiatives vary from providing/ distributing technology to facilitating the use of technology or developing technology (Bergvall- Karebom, Holst, & Stahlbrost, 2009). This then meant that for this study, specification of the second condition was necessary which was that the living lab chosen should be or should have been involved in development of a system towards development. Development in this case does not only apply to developing from scratch, but includes changing some aspects of the system so that it meets the identified purpose.

Research conducted identified at least ten living labs operating in South Africa [**16**,**28**]. Initial questions were sent to eight living labs to establish if they meet the criterion for the study and also to establish their interest in participating in the research. Based on the responses received, five living labs met the criteria for being part of the study but one refused to participate citing that the living lab only participates on research done with partners. During the visit for interviews, it was established that one of the four remaining living labs was still planning on developing the system and that left only three case studies.

Unstructured interviews were conducted in a sample that includes Managers or Coordinators of the living labs, System Developers and workers (when necessary).

For easy reference and to ensure confidentiality of identities of respondents, the following codes are used for case studies and respondents:

Table 1: Interview participants

Case Reference	Respondent Group	Respondent Reference
C1	Management team	C1M1
	Developer	C1D1
	Developer	C1D2
	Developer	C1D3
C2*	Management team	C2M1
	Developer/ Management team	C2DM1
	Developer/ Management team	C2DM2
	Developer	C2D1
C3	Management team	C3M1
	User	C3U1
	User	C3U2
	Developer/ Management team	C3DM1
	Developer	C3D1

Data from the interviews was analysed through thematic analysis using Atlas.ti™ and cross case analysis is used to present a holistic picture from these multiple case studies. Atlas.ti™ enables researchers to efficiently store, organise, manage and reconfigure data to enable easy human analytical use. Instead of manually grouping chunks of text, researchers can make use of Atlas.ti™ to categorise data into codes or themes relevant to the study in question [**29**,**30**]

6. Research Findings

From the interviews, there is a general consensus from the respondents that there is no formal decision on an SDM to be used for developing CISs. C3, however, have established their development methodology, although still not widely used nor documented. There is also awareness of the importance of using a methodological approach when developing a system. Importance of user input has also emerged as one aspect that needs to be considered during system development.

Another interesting finding from the study is the establishment of private companies that are linked to the living lab aimed at improving sustainability of living lab and also to ensure standards are adhered to during system development and to facilitate commercialisation of the systems developed. Research propositions below are used to summarise the findings from the study.

6.1 Research Propositions

The following propositions were compiled from interview responses:

a) Proposition 1
There is flexibility in choosing an SDM approach when developing CIS (C1, C2). The more mature the living lab is, the more formal its SDM approach is (C3).

b) Proposition 2
CIS developed in living labs are at different stages of deployment. C1 has not enjoyed stability in its development efforts due to the student focused development which results in poor continuity once a student finishes his or her studies. Most of the systems in C1 are not in use as there are some bugs that have not been solved. This situation is different from C2 who not only relies on student but also has full time developers on site thus student departure does not affect completion of the system. The CIS in C3 has gone through stages of development and is not in full use and this is due to a more stable environment offered by the full time developers from the private entity linked to the living lab.

c) Proposition 3
There are differing levels of user involvement during CIS development in the living labs (C1, C2, C3). User involvement is limited to the early stages of the CIS development process and during the system testing stages of the project (C1, C2). Some users of the C3 CIS are located in the living lab and thus easily become part of the CIS development process.

d) Proposition 4
Private entities are believed to be crucial towards better management of system development and commercialisation of CISs (C1, C2, C3). C2 and C3 have an already established private entity linked to the living lab and thus there are permanent employees. For C1 the private entity is still in the formation stages and thus students are still key part of system development.

e) Proposition 5
The nature of developers used depends on the circumstances of the living lab and the system at hand.

f) Proposition 6
Developers believe that SDMs are necessary to ensure that CIS development is a success (C1, C2, C3).

g) Proposition 7
Various contingent factors play part in the choice of a particular SDM to use when developing CIS (C1, C2, C3). Developers from C1 and C2 believe that size and the technological complexity of the CIS at hand play a role in the decision on whether to use SDM or not. C2M2 states "I think to do the job does not want a full methodology. If we a complex process where a database, you have to have a methodology". C3 on the other side add that urgency also plays a part in the decision to use SDM as sometime systems are needed urgently and thus the SDM used must accommodate the time pressures.

h) Proposition 8
SDM selection should be flexible, taking into account the community environment (C1, C3). It is important that user circumstances are taken into account when selecting an SDM.

6.2 Factors influencing the use of System development methodologies when developing CISs by living labs

Consideration of the system development environment is important when making decisions about an SDM to be used [**31**,**17**]. This became apparent during the interviews as there is constant reference to the living lab environment, the users, and the CIS being developed.

The propositions were instrumental towards identification of two components that have an impact on the use and effectiveness of SDM in living labs; the first one encompass factors relating to the living lab environment and the second component on factors relating to CIS development environement. Each of the factors is further expanded by variables which enable assessment of impact to one or more other factors.

Interaction between the factors and their variables give a better understanding of what lead to use or non-use of SDMs and thus their effectiveness. The two components are:

a) Nature of the living lab as it applies to CIS development.

These are factors specific to the living lab which have an impact on the decisions about CIS development.
1. *Location of the living lab*. Physical presence of the living lab has an impact on the extent of use or effectiveness of SDMs. People sharing the similar office space are most likely to adopt a particular approach to developing systems.
2. *Employment status of the developer*. This is often associated with *staff* [**31**,**32**]. This component is about the experience and the work arrangements of the project team. The tenure and responsibilities of the developers on development of the system has an impact on number of SDM areas, like the process, methodology use, user participation,etc.
3. *Existence of the private entity linked to the living lab*. Presence of a private entity supporting CIS development in the living lab has an impact on decisions surrounding SDM. For example, an established entity means that there is more structure and more learning from the system development processes.
4. *The CIS*. The impact of the size and complexity of the CIS was one of the statements that came more often from the respondents. Dependency on other systems, size and urgency of the system as contributers to the choice of a SDM .

b) CIS development factors.

These factors relate to the development environment of the CIS. The factors under this component are:
1. *User participation:* User participation has been identified as one of the key factors for the living labs.
2. *SDM approach:* Several factors on the living lab environment have an impact on decisions surrounding the use of an SDM approach when developing CISs
3. *CIS deployment status:* This is an account of whether the CIS was in use or not after it development.

Mapped into the elements of TOE, these factors can be presented as follows:

Table 2: Mapping of identified factors into TOE elements

Technology	**Organisation**	**Environment**
- The CIS - CIS deployment	- Employment status of the developers - Existence of the private entity linked to the living lab - SDM approach	- Location of the living lab - User participation

Living lab environment factors have an influence on the way in which the CIS is developed and deployed in the living lab. The decision to use an SDM has an impact on the deployment status of the CIS and the success of the system can be used to measure effectiveness of SDM.

An example can be used of a living lab with a permanent office, full-time developers, well established private entity and a complex CIS. An SDM is most likely to be used when developing this CIS due to stability created by same people developing systems and thus learning through experience over time. Also the fact that there is a private entity means that there is an expectation for more structured processes. This also affects the deployment status of the CIS. A conclusion can be made that living labs under these circumstances are most likely to make use of SDM and a working CIS has positive effect on perception about SDM effectiveness. This can demonstrated into the framework in figure 2 below.

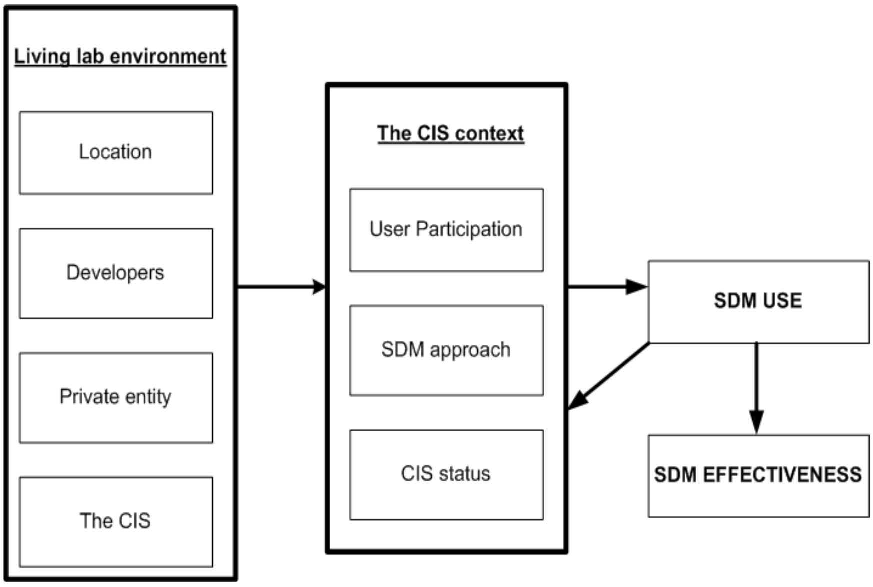

Figure 2: Framework for assessing the use and effectiveness of SDMs during development of CIS in living labs.

7. Conclusion

Results from the study have shown that there are gaps in the use of an SDM when developing systems for socio- economic development. Factors associated with the living lab environment have an impact on how CISs are developed. Living labs which have full- time presence in the community seem to do better in terms of standards and controls when it comes to system development. A linkage to a private company has also been established as a positive factor towards use of SDMs. This is evident from C3 which has full-time staff at the living lab and a thriving system that is being implemented globally. User involvement has also been identified as important towards successful development of CISs.
Based on TOE, the proposed framework shows relationship between the nature of the living lab and the CIS development context and their impact on the use and consequently effectiveness of SDMs when developing CISs.

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A resource management framework for sustainability of rural ICT4D in Zimbabwe

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Abstract

Developing countries are embracing Information Communication Technologies (ICTs) as a tool for alleviating poverty. There are, however, still challenges that developing countries face in trying to establish Information Communication Technology for Development (ICT4D). Among the major challenges is the lack of proper resource management which results in poor sustainability of Information Communication Technology for Development initiatives. If these ICT4D initiatives are to be sustainable for the benefit of current and future generations, proper resource management methods are to be developed and applied. This paper provides the results of a study that was conducted in rural Zimbabwe to investigate how proper resource management can influence the sustainability of Information Communication Technology for Development initiatives. Qualitative research methodology was used as a research approach for this study where two rural ICT4D initiatives were used as case studies. It was identified from the study that the lack of proper resource management methods adversely affects the initiatives' sustainability. It is upon this premise that this paper recommends a framework that can be applied to the management of Information Communication Technology for Development resources with the aim of achieving sustainability.

Keywords: *Information Communication Technology, Information Communication Technology for Development, sustainability, development, resource management.*

1. Introduction

ICT4D has gained popularity and is being implemented in many developing countries worldwide. According to Heeks (2009), ICT4D has evolved in three phases. Heeks (2009) explains that the first installation of a digital computer in a developing country in 1956 marked ICT4D 0.0, the rise of the Internet during the 1990's and the introduction of the Millennium Development Goals brought ICT4D 1.0 and that mobile devices and communication technologies gave way to ICT4D 2.0.

The challenges faced by developing countries engaging in ICT4D affect sustainability and contribute to the failure of some of these initiatives in Sub-Saharan Africa. Heeks and Alemayehu (2009) emphasise that failure must be avoided, considering the huge financial and resource investments made in the setting up of ICT4D projects. Harris (2004) defines sustainability as the capacity of a project to remain functional after its implementer has departed. Another definition is from Kumar (2005) who defines that sustainability of development projects is the ability to manage them in the long run. The same author also points out that such sustainability is yet to be achieved by many ICT4D players and it necessitates for the development of sustainability frameworks. This paper adopts the definition that ICT4D sustainability refers to initiatives that are adaptable to models that are suitable for a particular environment (Howard, 2008).

Zimbabwe is a developing country in Sub-Saharan Africa which faces the same challenges that most developing countries face in ICT4D, as well as additional challenges unique to the country. One of these challenges is the lack of evidence of proper ICT4D resource management, a challenge that this study seeks to address by designing a resource management framework. The resource management framework will guide ICT4D players in developing countries to focus on the proper acquisition and management of key ICT4D resources.

2. ICT4D in developing countries

The majority of the world's poor live in rural areas of developing countries hence most ICT4D projects are run in these regions (Cecchini & Scott, 2003). Initiatives like telecentres, living labs, public libraries and cyber cafes for public access to ICT have been introduced in rural communities (Gichoya, 2005; Bass, 2010). ICTs empower developing communities by enabling them to connect to global issues (Gomez & Baron-Porras, 2011). Some of the ways through which countries implement ICT4D to improve rural livelihoods are through e-Agriculture, e-Governance, e-Health and e-Education (Dutta & Mia, 2011).

In trying to implement ICT4D, developing countries face various challenges like poor infrastructure and electricity shortages and failures, software infections and reinstallations, remote management and transportation problems (Brewer, Demmer, Ho, Honicky, Pal, & Surana, 2006). These factors together with resource management and structural factors result in sustainability failure of most ICT4D projects (Kumar & Best, 2006). As identified by Marais (2011) limited education and skills in marginalised communities also contribute to lack of proper management which is essential for the sustainability of ICT4D projects.

Zimbabwe on its own has been through economic hardship since the year 2000 (Sachikonye, 2002). According to the Networked Readiness Index in the Global Information Technology Report of 2010-2011, this has resulted in the country being one of the last countries to embrace ICTs (Dutta & Mia, 2011). Power shortages, poor infrastructure, low bandwidth, brain drain, high telecommunications costs and lack of proper resource management techniques are some of the problems that Zimbabwe faces (Ndlovu, 2009). In order to ensure that ICT4D initiatives in Zimbabwe succeed, it is crucial to develop resource management framework that will enhance sustainability of the projects.

3. Management of ICT4D projects

Given the above mentioned challenges to the sustainability of ICT projects, it can be concluded that there is a crucial need to properly administer ICT4D projects to achieve the goals of alleviating poverty in marginalised communities. Macapagal (2010) points out that one of the causes for failure is poor project management. Macapagal goes further to recommend that responsibly managing resources invested can help capitalize on sustainable benefits. Macapagal and Macasio (2009) elucidate that the strategy to achieve the MDGs and international poverty alleviation policies is to implement ICT4D projects with good project management methods. The same authors further express that management is the key factor which influences either success or failure of ICT4D initiatives. Kumar and Best (2006) refer to management as one of the critical failure factors to ICT4D projects' sustainability. They argue that failure to make use of local capacities and to institutionalize the management structure can lead to sustainability failure. Management techniques adapted from industrial project management can be utilised in rural ICT4D projects with modification to suit the environment (Pade-Khene, Mallinson, & Sewry, 2011). The authors also suggest that it is important for the project leaders to consider the limitations of the community in order to design models which will ensure projects sustainability.

3.1. IT Governance and ICT4D projects management

In order to understand how ICT4D projects can be managed it is essential to consider frameworks in IT management. This study adopts the IT Governance Institute (ITGI)'s control framework called Control Objectives for Information and related Technology (COBIT) to explain the control processes which ICT4D organisations can apply to get good returns from IT investment (ITGI 2007). COBIT was created by the Information Systems Audit and Control Association (ISACA), and the ITGI in 1992 and was first published in 1996 (Abu-Musa, 2009). According to the ITGI (2007) the COBIT 4.1 supports IT Governance and so provides a framework called the IT Governance (ITG) framework which ensures that IT is aligned with the business to yield maximised benefits by responsibly using IT resources and appropriately managing IT risks.

The ITGI (2007) explains that IT Governance is a set of management structures and processes that ensure that projects' IT sustains and expands organizational goals. The ITGI definition of IT Governance shows that there is a relationship between sustainability and governance of an IT entity, ICT4D projects being the IT entity in the context of this study. According to Heeks (2002), 70 percent of IT projects fail due to lack of proper governance. This analysis proves the need for ICT4D projects governance structures that will help make projects succeed and become sustainable.

ICT4D resource management

Of relevance to this study is the resource management focus area of the ITG framework. According to the ITG framework, resource management is about the best management and investment in critical IT resources which are applications, information, infrastructure and people. It can be observed that these critical IT resources coincide with Kumar and Best's critical failure factors which are financial/economic, cultural/social, technological, political/institutional and environmental factors. Resource Management involves periodic monitoring of the investment, use and allocation of critical IT resources to make sure that present and future business goals are met (ITGI, 2007). This corresponds with the WCED (1987) definition of sustainability which states that present goals must be met without compromising future goals.

3.1.1 Managing applications

Developing countries implementing ICT4D face the challenge of high applications and software maintenance costs which results in projects' financial un-sustainability (van Reijswoud, 2009). Based on this, it is crucial to develop techniques for the cost effective management of ICT4D applications to achieve sustainability. Macapagal (2010) classifies applications and software under technology and highlights that technology should not dictate project needs but it should be used to sustain the people's needs. An ICT4D initiative contains applications as elements of the project system. It is imperative to properly manage applications to ensure continuous and effective running of the ICT4D project. The kinds of applications that are used in an ICT4D project depend upon the function and purpose of the initiative. As an example, an e-Agriculture project can make use of Global Positioning Systems (GPS) for map making and surveying, Automatic Milking Systems (AMS), or Geographic Information Systems (GIS), among others (Cecchini & Scott, 2003).

3.1.2 Managing Information

Information is a product of raw data that is input, processed and output by the information systems for meaningful use by the business (ITGI 2007). Walton and Heeks (2011) identified that the high failure rate of ICT4D projects calls for new management techniques, COBIT 4.1 is one of such frameworks that can bring positive impacts upon the ICT4D field if appropriately applied. The ITG framework demonstrates that IT enterprises need to do to provide reliable and consistent information and to flawlessly incorporate applications into the business processes. These controls can be applied to the internal functionings of an ICT4D project. Applying the controls will involve seeing ICT4D projects beyond just being development initiatives and treating them as information systems which need to be run by IT Governance principles. This will result in robust management structures which can be sustained for long-term periods.

3.1.3 Managing Infrastructure

Infrastructure is the machinery and amenities that facilitate the processing of the applications (ITGI, 2007). The ITGI (2007) states that in order to maintain ongoing technological support there is need to strategically plan the acquisition, maintenance and protection of infrastructure. According to the ITGI this can be achieved by creating a technology acquisition and maintenance plan and applying internal control, security and auditability measures. The ITGI mention that this can be measured by percentage of infrastructure that are not meeting the defined IT architecture and technology standards, the rate of crucial processes using outdated infrastructure and the rate of infrastructure units that are no longer manageable. The ITGI (2007) further recommends continuous training of staff to enhance successful operation and use of the system. ICT4D projects are implemented in environments where there is lack of skills; user training is crucial and beneficial for the sustainability of the projects (Bailey, 2009). According to the ITGI (2007) users, managers, support and operational staff must be trained and training documentation must be produced for knowledge transfer. To measure this, the ITGI recommends the design of a plan for documentation of all operational aspects and to transfer knowledge to managers, end users and operational and support staff.

3.1.4 Managing People

People are the human resources needed to run the information systems and operations (ITGI 2007). In the ICT4D context people refers to all project stakeholders. Projects are designed, implemented and managed by people hence the needs of the people are to be prioritised and a sense of ownership must be conveyed to the people (Macapagal, 2010). Macapagal and Macasio (2009) refer to stakeholders as 'people' in the ICT4D project and they state that stakeholders should be involved at every stage of the project. An ICT4D project's stakeholders include; project beneficiaries, project service providers, ICT developers and providers and funding entities (Tongia & Subrahmanian, 2006). It is important to properly manage stakeholders for the sustainability of ICT4D projects. However, there are challenges which include difficulty in identifying the stakeholders, lack of openness among the stakeholders and the subjectivity of their classification (Bailur, 2007). Bailur therefore proposes a perspective to counter these challenges. Bailur (2007), Macapagal & Macasio (2009) and Macapagal

(2010) all agree with ITGI (2007) that people must be suitably managed right from start for ICT4D projects to succeed.

3.2. ICT4D sustainability

The high rate of failure in ICT4D initiatives has raised global concern for the projects sustainability (Grunfeld, 2007; Heeks, 2008; Naik, Joshi, & Basavaraj, 2010). Walton and Heeks (2011) suggest that sustainability in ICT4D can be achieved through change in the approaches that are used in implementing projects. Grunfeld (2007) also argues that ICT4D projects can be sustainable if they are improving peoples livelihoods and if the infrastructure and resources are efficiently managed. This implies that there is a relationship between effective use of ICT4D resources and the achievement of maximum benefits from ICT4D investment. The more people properly manage ICT4D resources, the more they benefit from the ICT4D initiatives.

4. Methodology

An interpretive paradigm was applied to carry out a real-life investigation of the rural ICT4D projects. In order to find out how ICT4D projects are currently managed in rural Zimbabwe, there was need for the researcher to immerse into the context, to study how the involved actors' behaviour affects particular situations. Adopting the Interpretivist paradigm allowed the researcher to study the context itself, resulting in non-numeric data that portrays the real world situation in rural ICT4D. This aided identifying the factors affecting ICT4D projects' sustainability and what can be done to improve it.

The study applies a qualitative approach, using a case study research method. The qualitative approach was chosen because the nature of phenomena to be analysed were subjective and inseparable from their context (Creswell, 2003). The research aims at identifying characteristics, causes and effects of the phenomena under study, hence the use of qualitative approach. Interviews, observations and document analysis were utilised to elicit data on resource management and sustainability of the rural ICT4D projects.

The two cases used in this study are Mutoko World Links ICT Centre and Practical Action Podcasting Project, Guruve. Mutoko World Links ICT Centre runs at the Mutoko Government High School in Mutoko, a rural area situated within the Mashonaland East province of Zimbabwe. The centre opens to students and teachers during normal school hours and to the community after school hours and on weekends. The approximate number of served by the Mutoko World Links ICT Centre is 250 people (students and communal users). The centre offers ICT related services and training to students and teachers with the aim of improving their educational and employment opportunities as well as linking them with their counterparts across the world. The Practical Action Podcasting Project runs in Guruve, Mashonaland Central Province of Zimbabwe. It serves over a 300 farmers in the area. The project was conducted by Practical Action partnering with the Lower Guruve Development Association (LGDA). Podcasting facilitates knowledge sharing among farmers in the local Shona language. Practical Action captures the knowledge of and agricultural experts, and puts it onto MP3 devices can record and replay any voice file using local languages.

The population used for data collection constitutes all the stakeholders of the two projects. Purposive sampling was used to select the sample for the data collection. From the population, purposive samples were taken from project managers, communal users and project staff members. This sampling method was deliberately chosen due to the differences in populations per project and the detailed information required from the interviews and observations. Only relevant documents were assessed (documents which portray resource management and sustainability issues).

This study employed an inductive approach. The procedures to be used for analysing data from the case study are adopted from Marshall and Rossman (2010). The authors divided the process of data analysis into seven (7) procedures. The procedures have been chosen due to their inductive, theory generating nature. The findings gathered from the data were used to create the framework. The procedures are shown in Figure 1 below.

STEP 1	STEP 2	STEP 3	STEP 4	STEP 5	STEP 6	STEP 7
ORGANISING DATA	IMMERSION IN THE DATA	GENERATING CATEGORIES, THEMES & PATTERNS	CODING THE DATA	INTERPRETATION THROUGH ANALYTIC MEMOS	SEARCHING ALTERNATIVE EXPLANATIONS	WRITING THE REPORT

Figure 1. Data Analysis Procedures

5. Findings and data analysis

Projects' goals and objectives:
Mutoko World Links ICT Centre
The project aims at transforming Zimbabwean education through the use of ICTs. Their objectives are to promote the use of ICTs in education and to promote collaborative learning and ICT skills.
Practical Action Podcasting Project, Guruve
The aim of the project is to facilitate knowledge sharing among farmers in the local Shona language by capturing the knowledge of and agricultural experts, putting it onto devices can record and replay any voice file using local languages.

Projects' sustainability goals:
Mutoko World Links ICT Centre
The centre trains teachers, students and members of the community in computing skills. Trained teachers become key persons (champions) in the community and become the ICT resource persons. These resource persons gain capacity to conduct workshops on ICT awareness with the community. The Mutoko World Links ICT Centre also sells ICT equipment to the community and provides ICT services such as internet, documents processing and email at subsidised rates.
Practical Action Podcasting Project, Guruve
The podcasting equipment provides a source for knowledge sharing to rural areas that have electricity shortages and poor radio and internet connectivity. The content is available for use in troubleshooting agricultural problems even when experts are not available. Farmers meet on field days to listen to the podcasts, this fosters development through collaboration.

ICT applications used in the projects:
Mutoko World Links ICT Centre
The centre makes use of various applications for word processing, student research, internet surfing and virtual learning. Examples of such software include Microsoft Office, Adobe Photoshop, Adobe Acrobat, Internet Explorer and Mozilla Firefox. Most of this software however is out of date and there were several correspondences that were being made to seek for funding to get more up to date software packages.
Practical Action Podcasting Project, Guruve
The software in use for the podcasting project includes voice recording software for the capturing content, word processing software for documentation and internet software for research.

Barriers and challenges to ICT use faced by the community:
Mutoko World Links ICT Centre
Out of the 13 available computers in the lab, 4 are Pentium II, 7 are Pentium III, and 2 Celerons, these computers are slow in processing. There is only one computer teacher at the centre who is also the project coordinator. The same teacher is the one who is also responsible for repairs and maintenance of the computers, spare parts are not available due to shortage of funds. Some users come from villages that are very far from the centre hence some of them are not able to attend lessons consistently.
Practical Action Podcasting Project, Guruve
The podcasting devices need to be recharged and some village farmers are located far from the centre and the cost of travelling is high for them. Solar powered iPods have been designed to solve the power problems but they are few of them available. Some lead farmers who keep the devices might be unwilling to share with others; this can pose a disadvantage for some users. The iPods sometimes can get dysfunctional and the technicians are not available so it takes time for the devices to be repaired. There is fear from community leaders that the iPods might be used for political information dissemination, however caution has been exercised to avoid such.

Resources available in the project:
Mutoko World Links ICT Centre
Infrastructure: roads, electricity, computers, computer lab, internet dongles, power generator, printers. The roads in Mutoko are not tarred and they are sandy, such that it is difficult to drive especially in rainy seasons. There is only one computer lab and there are plans to build two other labs. There is no internet connectivity and users rely on dongles to gain access to mobile internet which is currently expensive, for example a dollar (us$1) buys 10 megabytes of data bundles. Electricity supply is poor and the centre relies on the generator which needs to be fuelled.
Information: The centre keeps personal information about the staff, students and users. This information includes organisational documentation, users' personal details, information from clients served and training materials. Some of this information is confidential and it needs to be protected.

People: the people aspect constitutes all the project stakeholders. For the Mutoko World Links ICT Centre there is a project director, project coordinator, the committee, teachers, communal users and students. The project director who is also the Mutoko Government High School Headmaster oversees the running of the Mutoko World Links ICT Centre. The project coordinator is the one who runs all the centre activities and is also the ICT teacher. The committee comprises teachers from the school and some community leaders. The students are from the school and some users are members of the community who use the lab after school hours.
Applications: The applications used at the centre are mainly Microsoft Office software, internet software and document processing applications.
Practical Action Podcasting Project, Guruve
Infrastructure: computer for recording voice, iPods, solar panels, cell phones, speakers, mp3 players, charging equipment, roads, mobile network boosters, offices, training centre
Information: stored information covers content on crop production, livestock production and health programs.
People: the people involved in the project are the project director, project coordinator, local farmers, extension workers,
Applications: internet software, Microsoft office, windows, recording software and voice compressing software

Projects Resource Management:
Mutoko World Links ICT Centre
There are rules and regulations for using the ICT lab. These general lab rules guide users on how to use computers and applications safely for protection against computer viruses and device damage. There are locks and gates to physically secure the lab. An inventory of equipment is maintained at the centre and at the World Links head office
Practical Action Podcasting Project, Guruve
The Finance department and the Board keep record of assets. The podcasting equipment is owned by the community, but it is managed by the project staff. All computers are numbered and recorded in the asset register. Software is regularly updated and there is a safe for external backup. Cyber backup is utilised as well to save online copies of information. All doors and windows are lockable and there are 24 hour security guards. Only trained personnel need to be approved to use the podcasting system. Quarterly development meetings are held to check the podcasting equipment.

Sustainability goals of the current resource management approaches:
Mutoko World Links ICT Centre
The available Lab rules and regulations are aimed at preserving the current equipment for as long as possible. The current challenge is that the funds generated by the centre are inadequate to facilitate maintenance and acquisition of new resources.
Practical Action Podcasting Project, Guruve
The project aims at achieving sustainability through safeguarding the available resources so that they can be used by the current and future generations. They are also training farmers to develop a sense of ownership so that they value the resources.

Adoption of other ICT project resource management approaches:
No other ICT project resource management approach has been adopted in both projects.

Resource management plans available:
There are no resource management plans set for both projects besides the measures they are currently implementing.

Continuous monitoring and control of the resource management process:
Currently there is no continuous monitoring and control of the resource management process for both projects.

Plans for improvement in the existing resource management methods:
There are no plans for improvement in the existing resource management methods in both projects.

6. The resource management framework

The proposed resource management framework is adapted from the theory of the resource based view of the firm (RBV). Literature shows that the RBV has been used more in the information systems (IS) research for the commercial sector (Caldeira & Ward, 2001; Wade & Hulland, 2004; Liang & You, 2009) than in ICT4D research (Chan, Hackney, Pan, & Chou, 2011). The RBV can be adapted for use in ICT4D research to aid study on properly managing resources to achieve long term sustainability. The central concept of the resource based theory is that organisational performance is dependent on its existing resources (Liang & You, 2009). Wade and

Hulland (2004) explain that the RBV describes that an organisation's resources enables it to gain competitive advantage and long term success. The premise that the RBV is principally oriented on resources and capabilities makes it relevant for this study. In the ICT4D context sustainability can be prioritised as the main focus in place of competitive advantage. Using this theory, the findings and data analysis results from this study have been used to design a framework that illustrates that proper resource management leads to ICT4D success, which results in long term ICT4D sustainability. Figure 2 below shows the Resource Management framework derived from this study.

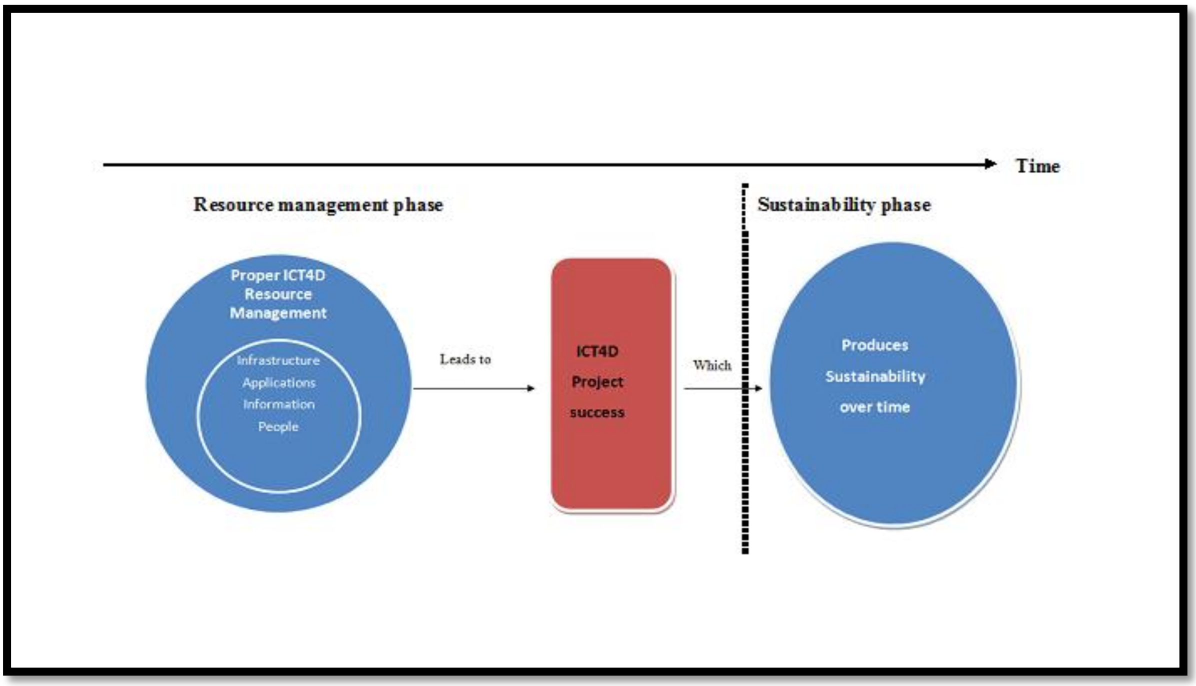

Figure 2. The proposed resource management framework (adapted from Wade & Hulland, 2004)

7. Framework Evaluation

The framework evaluation method to be applied is Expert Validation. The proposed resource management framework will be sent to ICT4D experts for validation in order to evaluate its significance to rural ICT4D sustainability. The evaluation will be based on the following criteria:

1. Simplicity – to evaluate if the framework can be easily understood by rural ICT4D players.
2. Relevance – to evaluate the framework's potential to improve rural ICT4D sustainability.
3. Strengths and weaknesses – to evaluate the framework's strengths and weaknesses, to enable further refinement of the framework.

8. Conclusion

Proper resource management methods are essential for the sustainability of ICT4D projects in rural Zimbabwe. Resource management is about the best management and investment in critical IT resources. ICT4D projects are composed of critical IT resources which are applications, information, infrastructure and people. The study reveals that ICT4D projects in rural areas of Zimbabwe currently lack defined resource management techniques. The absence of defined resource management results in lack of procedures to monitor and control how resources are acquired and managed. It was observed from this study that over time organisations end up with obsolete or inadequate resources, thereby hindering the achievement of the intended project goals.

The results of this study also indicate that rural ICT4D projects in Zimbabwe have no future plans for resource management. In addition to this there are currently no measures to link resource management with sustainability goals. Failure to set procedures for managing resources leaves room for improper maintenance of resources, resulting in sustainability failure. There is need for continuous monitoring and control of the resource management procedures as well as the need for improvement planning. This will help ICT4D implementers to learn and upgrade their resource management skills to enhance project sustainability.

Applying the COBIT 4.1's resource management principles to the governance of ICT4D projects in rural areas would help organisations to properly manage resources for the benefit of both the current and future generations, resulting in sustainability. It is anticipated that after evaluation and improvement, the proposed framework will be sent to the rural areas under study for application and implementation.

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Dedication to Corporate Social Responsibility: The Bhilai Steel Plant Case in India

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Abstract

Service learning is a form of experiential education that integrates meaningful community service with instruction to enrich the learning experience, teaches civic responsibility, encourages lifelong civic engagement, and strengthens communities for the common good. Likewise, Corporate Social Responsibility (CSR) is the way firms integrate social, environmental and economic concerns into their values and operations in an accountable manner. Bhilai Steel Plant (BSP) situated in Chhattisgarh state, India is the flagship unit of the Steel Authority of India Ltd. It uses the most advanced technology in all related fields producing more than 5 million tons of steel annually and employs around thirty thousand people. The well qualified HR personnel of BSP, have studied the concepts of CSR in college, have propagated the ideas amongst the line personnel and are now applying the concepts in their working lives. BSP also believes that society and industry are interdependent and both can act to benefit each other mutually. This has successfully established BSP, as a "caring and sharing" brand. Instead of focusing on CSR activities as a strategic move to expand business, BSP has taken a holistic view of the deep interconnection between the society and the organization appreciating the symbiotic relationship between the two.

Keywords: *service learning, corporate social responsibility, experiential education, civic engagement.*

1. Introduction

Service Learning (SL) is a concept taking root in the current academic system to make the incumbents aware of the practical application of their education in community service. This concept consists of incorporating topics on subjects like civic responsibility, encourage lifelong civic engagement, and strengthen communities for the common good in the learning curriculum [1] so as to prepare the minds to undertake some social cause that imparts a sustainable socio economic development. When these minds combine their education with a sense of responsibility towards the society and embark on earning a livelihood, they are now aware that they have to use their learning to make a meaningful contribution towards enhancing social values. Service Learning is the basis on which Corporate Social Responsibility is perceived and executed as it is the direct result of the practical concepts learned here. Therefore Service Learning transforms mere pedagogy to something more substantial. It actually directs the scholar to add value to his/her vocation by participating in bringing about a positive change in society. Different ways of service learning are:

A). Direct service learning- where students interact directly with individuals by tutoring, helping and supporting the elderly, disabled or affected person.
B). Indirect service learning- where they join hands with projects or NGOs in strengthening social values.
C). Advocacy service Learning – Students speak, write or review literature on subjects that need to be addressed on social fronts.

D). Research service Learning – Where students collect data, suggest methods and undertake projects to support and explore new possibilities in community service [2].

We have been impressed upon from time to time that any organization within a society is using its resources and thereby depleting them in the process of production of goods or services. Therefore, they are expected to payback the society by undertaking activities that are reformative like tree plantation, sanitation and hygiene, education, gender and social equality, etc. and thereby replenish and restore to the society a part of these resources. These activities come under the term Corporate Social Responsibility (CSR). Both SL & CSR are deeply inter-woven. While Service Learning enriches the learning process by teaching how to execute this responsibility even while receiving formal education by incorporating practical community service as a part of their educational philosophy, CSR is the way firms integrate social, environmental and economic concerns into their values, culture, decision making, strategy and operations in a transparent and accountable manner and thereby establish better practices within the firm, create wealth and improve society [3].

Understandably in most of the developing countries still battling to cross the benchmark of a civilized society, this is a far-fetched concept. Nevertheless, Corporates are becoming aware of their responsibility towards the community within which they function. The reason could be due to a growing focus on corporate ethics, government intervention to curb unfair business practices and media watch or the intention of promoting stakeholders goodwill [4] - [6]. It could also be the result of a sense of philanthropic fulfillment. Whatever the reason, we now come across activities undertaken by institutions to improve the socio economic conditions around them.

One of the best examples presented here for study is the case of the Bhilai Steel Plant (BSP) in India which is the flagship unit of the Steel Authority of India Ltd (SAIL). The HR personnel of BSP who had studied the concepts of corporate social responsibility in their college days, are all well qualified for their job. They have already propagated the ideas amongst the line personnel and are now applying the concepts in serving the society. BSP also believes that society and industry are interdependent and both can act to benefit each other mutually. This has successfully established BSP, as a “caring and sharing” brand. Instead of focusing on CSR activities as a strategic move to expand business, BSP has taken a holistic view of the deep interconnection between the society and the organization appreciating the symbiotic relationship between the two.

Many of the BSP executives have MBA degrees from reputed institutions across India, where CSR is a compulsory subject in the course. Moreover the technical and management executives also have Engineering degrees from IIT (Indian Institute of Technology) and other established institutes where subjects like ‘*Humanities’* are taught to build an awareness among the scholars about their responsibilities towards mankind. To add better credibility to these subjects, almost all IITs are associated with NSS (National Service Scheme) where students undergo a practical experience of social service. When these personnel joined the BSP after graduation, they brought along with them a motive of dedication towards social service learnt from both theoretical as well as experiential education. They have in turn impressed upon their superiors and subordinates, the responsibilities towards society. BSP is committed to share the benefits accrued through its just and ethical business for the socio-economic development of people around and creating a sustainable environment.

1.1 *Guiding Principles for CSR in BSP:*

BSP’s CSR activities are guided by the following main principles [7], [8]:

- Align business operations with social values. Bring about a meaningful difference in people’s lives.
- Identify and strengthen weak economic zones in peripheral areas.
- Empower people especially women for self employment.
- Taking care of Education, Health and Sanitation.
- Minimize environmental hazards.
- Promotion of folk art and culture of the region.

For a wider coverage, the initiatives have included Peripheral Development, creation of Model Steel Villages (MSV), developmental work in mining and tribal areas, women empowerment, promoting self employment, supporting NGOs, promotion of sports and games, etc. An average two percent of the annual net profit of BSP is spent on the major CSR activities like the health care, education, township and non-statutory welfare activities [8].

2. Review of Literature

The Community Service Act of 1990, which authorized the Learn and Serve American grant program, defines service learning as:

"a method under which students or participants learn and develop through active participation in thoughtfully organized service that is conducted in and meets the needs of a community; is coordinated with an elementary school, secondary school, institution of higher education, or community service program, and with the community; and helps foster civic responsibility; and that is integrated into and enhances the academic curriculum of the students, or the educational components of the community service program in which the participants are enrolled; and provides structured time for the students or participants to reflect on the service experience."

It is evident from the above that practices of community welfare are integrated in educational courses in the service learning process with a view to train scholars and build awareness among them concerning their civic responsibilities as educated citizens. When a student participating in such a program reflects upon the outcome, he/she is inspired to continue these activities throughout life as they derive immense satisfaction from them.

Two philosophies have been instrumental in the formation of Service-Learning; progressivism and pragmatism and these ideas are popularized by John Dewey and William James. While progressivism is a term used to describe educational methods different from traditional methods, stressing the need for doing things practically or getting personally involved in humanitarian programs as a part of education process, pragmatism comes from the Greek word *pragma* meaning action. When Education combines principles with actual performance, it becomes more emphatic and leaves a lasting impression in young minds producing citizens more conscious of their roles in the evolution of an ideal society.

The term "corporate social responsibility" came into common use in the late 1960s and early 1970s after many multinational corporations formed the term stakeholder, meaning those on whom an organization's activities have an impact. It was used to describe corporate owners beyond shareholders as a result of an influential book by R. Edward Freeman, Strategic management: a stakeholder approach in 1984. D Wood, in his work 'Corporate Social Performance Revisited' (1991) 16(4) for The Academy of Management Review, defined Corporate Social Responsibility as corporate conscience, corporate citizenship, social performance, or sustainable responsible business. Responsible Business is a form of corporate self-regulation integrated into a business model. CSR policy functions as a built-in, self-regulating mechanism whereby a business monitors and ensures its active compliance with the spirit of the law, ethical standards and international norms.

The SAIL CSR brochure highlights its commitment towards building a society that shows remarkable achievements in establishing high economic, ecological, educational, health and sanitation, infrastructure, cultural and social standards. Corporate Social Responsibility in SAIL is a continuous process that identifies areas for improvement and commits itself to this intention [7].

3. Rationale behind this study and Research Methodology

This study is being presented here to reflect upon the fact that Service Learning can be effectively treated as a foundation on which a practical social welfare program can be based on, when extended and integrated into the organisational objectives. It elaborates on the success of Bhilai Steel Plant, a unit of SAIL in achieving momentous development in the overall social scenario, by its CSR policy derived from service learning of their personnel in their academic days.

This study is an attempt at highlighting the fact that in spite of being based in a developing country like India, lack of resources has not restricted the organisation from adopting plans for all-round community welfare. It goes to show that CSR is not the prerogative of developed countries only but can be integrated into the business plans of industries in every country however insignificant it may appear. It may be noted here that in developing countries like India, the majority of the unskilled labor come from BPL (Below Poverty Line) families and are deprived of even the basic facilities like hygiene, health, medical treatment, drinking water and literacy. It does not need large corporations situated in developed countries to initiate welfare programs for these people. BSP has proven without doubt that every industry regardless of its operating ground can provide benefits, however small, to their employees.

It may also be pertinent to mention here that the main product of BSP is steel which is manufactured by using iron ore as raw material. BSP is aware that continuous mining depletes the mines of their natural reserves. The smelting process done in massive sized furnaces using coal as fuel involves depletion of coal reserves as well. Although it is ensured that production technology involved causes minimum damage to the ecology, BSP compensates by undertaking an extensive tree plantation drive. Like any other industry BSP also uses the infrastructural facilities such as land, water, roads, power and other resources needed for effective functioning and therefore, it endeavors through its CSR plans to repay the society.

The HR Personnel of BSP have initiated and developed programs inspired from the concepts learned during their coursework and have extended this philosophy to Corporate Functioning as well. A review of their programs can be used as a guideline for other organizations both in private and public sectors to use Service Learning as a guiding concept in furthering their responsibility towards the community.

The programs undertaken by SAIL and discussed here may be used as a benchmark for other organisations keen on contributing a part of their profits towards welfare activities beyond business strategies.

The research methodology adopted here is from the study based on the first-hand reflection by one of the authors who is a retired Acting General Manager from BSP. Since he headed and had been a part of many such CSR initiatives, he has presented here a list of all such activities undertaken as community service and also assigned credit to service learning during his higher education.

The authors have also studied in depth and observed the welfare plans implemented by BSP in the township and in the surrounding areas like health and sanitation, supply of filtered drinking water, garbage disposal, education, promotion of art and cultural activities and provision of sport facilities to their employees and their dependents. They have personally interviewed the management personnel as well as the beneficiaries of the plans to establish credibility to the research. Questions were designed carefully to establish a distinct relation between Service Learning during pedagogy and CSR. Some of the data have been presented from the annual reports, Chairman’s address and reports published in dailies giving an insight into the CSR program.

4. A Brief Introduction to Bhilai Steel Plant

Bhilai Steel Plant is one of the first three integrated steel plants set up by Government of India to build up a sound base for the industrial growth of the country. The agreement for setting up the plant with a capacity of 1 Mt of Ingot steel was signed between the Government of erstwhile U.S.S.R. and India on 2nd February, 1955 and after a short period of 4 years, India entered the main stream of the steel producers with the commissioning of its first Blast Furnace on 4th February, 1959 by the then President of India, Dr Rajendra Prasad. Bhilai expanded its production capacity in two phases - first to 2.5 Mt which was completed on September 1, 1967 and the 4 Mt- 2nd stage which was completed in the year 1988.

All the units of the plant have been laid out in sequential formation according to technological inter-relationship so as to ensure uninterrupted flow of in-process materials like Coke, Sinter, Molten Iron, Hot Ingots as well as disposal of metallurgical wastages and slag etc., minimizing the length of various inter-plant communications, utilities and services.

As an integral part of SAIL's growth plan that envisages capacity augmentation to around 23 Mt crude steel in the near future, projects worth Rs.172650 million are being executed for Bhilai's expansion and modernization, after which Bhilai's capacity would be enhanced to 7.5 Mt hot metal and 7 Mt of crude steel [7].

Bhilai has its own captive mines spread over an area of 4372 hectares. Iron ore is available from Dalli-Rajhara group of mines, 85 km south-west of Bhilai. Limestone requirements are met by Nandini mines, 20 km north of Bhilai and dolomite comes from Hirri in Bilaspur district, 135 km north-east of the plant. To meet the future requirement of iron ore, another mining site Rowghat, situated about 100 km south of Rajhara is proposed to be developed; as the ore reserves at Rajhara are depleting.

It is the first integrated steel plant with all major production units and marketable products covered under ISO 9002 Quality Certification. This includes manufacture of blast furnace coke and coal chemicals, production of hot metal and pig iron, steel making through twin hearth and basic oxygen processes, manufacture of steel slabs and blooms by continuous casting and production of hot rolled steel blooms, billets and rails, structurals, plates, steel sections and wire rods. The plant's Quality Assurance System has been awarded ISO 9001:2000 certification.

Bhilai has obtained ISO 14001 certification for its Environment Management System and for its Dalli Mines. Bhilai is the only steel plant to have been awarded the Government of India's prestigious Prime Minister's Trophy for the best integrated steel plant in the country eleven times out of the total sixteen times it has been awarded so far.

5. Scope of CSR Activities in BSP

Interestingly, though the coinage of the phrase `CSR' is not very old, BSP in India has been a pioneer in these initiatives from the very beginning of its inception about fifty five years back. While the statutory welfare of employees include only the commons like first aid, urinals, washing places, canteens, labor welfare officers, etc, BSP has ensured that the non-statutory welfare activities for its employees and their families far exceed the legal requirements and include major initiatives like a very well maintained township with modern amenities, 1000-bed hospitals and a large educational set up with facilities for almost free education to the employee-wards and other children of the society. Thus, BSP's CSR activities are not limited to the CSR as understood in common parlance. The other major contributions are also briefly detailed below.

5.1. Bhilai Township

With nearly two hundred thousand residents, an ISO 14001 certified Bhilai Township is maintained and managed by the Town Services Department. Town Services Department caters to housing, maintenance; education, environmental hygiene and civic amenities needs of the residents of township. Its main objective is to serve employees to live a pleasurable and peaceful family life.

Having an area of around 3200 hectares, Bhilai township houses 35,954 residential units, 109 public buildings (including 41 schools, 2 hospitals, 9 health centers, 14 clubs and community centers), lease shops, parks, stadiums, etc. Daily consumption of water in the township is around 64 million litres, while electricity consumption of approximate load is 32 MW (average).

5.2. The Medical Set-Up

The medical set up of BSP aims solely at providing complete health care not only to the employees but also to the common people at Bhilai and the neighboring places from a radius of about 800 km. It employs nearly 200 doctors, 15 non-medico executives and 1200 non executives including about 400 nurses and 800 paramedical staff. Health care facilities have been spread over a number of hospitals and health centers both at Bhilai township and its captive mines locations with a total of 1000 bed capacity including the major share of 860 beds at the main hospital. Four other hospitals and 14 health centers have been set up to provide 'on the spot' service at different locations of the township and mines. The OPD attendance is more than one million patients and the indoor patients number about 50,000 yearly.

5.3. Education

Education is the best legacy a nation can give to its citizens. BSP has excelled in providing exemplary service in both the categories of academic performance, namely the administrative factors at the government and institutional levels and the socio-economic factors. With 83 schools and 2300 teaching staff, the education system of BSP shaped the future of 65000 young Indians in 1986 which now with the advent of a large number of other institutions has remained nearly 40% of its 1986-size. But, this has certainly provided an opportunity to improve the quality of education manifold with stupendous rise in the pass percentages, selections in various competitions and performance in co-curricular activities.

5.4. Ancillary Development

Bhilai Steel Plant supports about 170 ancillary industries in the small-scale sector in and around Bhilai. The plant places assured supply orders on these industries to ensure their smooth and continuous production performance. The plant provides all necessary technical guidance to them including selection of product and raw material, preparation of project reports, stage inspections etc. Another very important support to these ancillaries comes in the form of necessary technical training to their workforce with the help of all equipped training institutes of Bhilai Steel Plant. In fact BSP has been playing the role of `big brother' for the small scale industries of the region [8].

5.5. Vocational Training

Bhilai Steel Plant has been providing vocational training to about 5000 students every year coming from various professional institutes of different parts of India including polytechnics, engineering colleges, management institutes, nursing colleges, medical colleges, colleges of safety engineering, etc. [7], [8].

5.6. CSR – SPECIFIC

Bhilai Steel Plant had long realized that its operations have major impacts on the communities in the nearby areas. In 1963, the Community and Peripheral Development department was started and this department started running primary schools, girls' schools and Adult Education Centers in the deprived camps and neighboring villages in order to take care of the residents of the area.

In 1978, the area was increased to a radius of 8 km around the Town Administration building encompassing 31 villages and then later in 1983, the radius became 16 km with 136 villages. Thus, it was in 1978 that Bhilai Steel Plant started sharing its prosperity with neighboring villages through the construction of additional rooms in village schools, making roads, bridges, culverts, buildings for Local Self Government, Community Halls, Cultural stages, digging bore wells, deepening villages tanks/ponds, making bathing platforms at the ponds for safe bathing and other such activities. Subsequently, activities involving community health were taken-up.

The Community and Peripheral Department with the help of the Medical Department and Public Health Department conducts eye camps, general OPD camps, Ayurvedic camps. Veterinary camps, cancer detection camps, aids prevention and awareness programs are held regularly [8]. The department is running one English medium middle school and one health center dedicated solely to the 'below poverty line' residents of the locality. Their efforts in the field of women empowerment, particularly through self employment have received wide recognition in the country.

Bhilai Steel Plant has actively been involving in the preservation and promotion of folk art and culture of the region, the 37th such Festival was held in May 2013. Over the years, more than 1000 groups/parties have participated in this annual event, giving an opportunity to more than 10000 local artists to perform on the stage. Some of these artists, such as Mrs Teejan Bai, Ms Ritu Verma and Late Mr Devdas Banjare have won international acclaim for their art and it is a matter of pride for Bhilai Steel Plant that they all started their careers from this stage. Disaster Management is another area where the CSR of BSP is reflected in all its dedication and largesse. A sum of Rs.10 millions was made available for the disaster victims of the 2004 Tsunami. Ongoing CSR activities of BSP are briefly presented in Table-1.

Table-1 Ongoing CSR activities in Bhilai Steel Plant

Location	**Work description**	**Budget in thousand rupees**	**Date of start**	**% of work completed**	**Expenditure incurred in thousand rupees**
Bhilai and MSVs	Regular Medical camps in MSVs	3400.00	April, 2012	25%	169.00
Bhilai	Running of school for under privileged children	3100.00	April, 2012	25%	170.00
Bhilai	Education of Tribal children	4500.00	April, 2012	25%	63.00
Bhilai	Education of Tribal nursing girls	500.00	April, 2012	25%	75.00
Schools around Bhilai	Mid day meal scheme	11000.00	April, 2012	25%	550.00
Bhilai and MSV	Various income /skill generation activities	1500.00	April, 2012	10%	80.00
Roads	Road side tree plantation- 50 km long	544.00	September2010	80%	277.00

6. Recapitulations

BSP accepts its social obligations to the communities in which it operates by promoting concepts of national integration in its broadest sense by providing community services, developing and assisting domestic institutions and generally ensuring that the Company as a whole and its employees act on the ideals of social justice without discrimination. It provides technical know-how and financial assistance for establishment of hundreds of ancillary industries and assures minimum orders of supplies to them. The BSP encourages talent and growth among the members of the communities through assistance towards the establishment of cooperative institutions, carrying out programs for peripheral development and supporting educational, charitable and welfare institutions. It is providing healthcare by way of regular health camps and health centers among other initiatives, within and outside the steel township; and undertaking programs for controlling air pollution, water contamination and disposal of solid wastes aimed at environmental preservation [8]. BSP is an inseparable unit of SAIL and SAIL set the context for sustainable development. It has taken up the challenge to go beyond statutes and voluntarily weave corporate social responsibility into its business operations. As a result, SAIL has espoused responsible competitiveness whilst continuing to be the largest Indian steelmaker. Further, in their respective areas of operations, SAIL plants like BSP have converted into reality SAIL's social obligations to its communities by implementing several initiatives since the 1960s [7].

7. Conclusion

If corporations restrict themselves to attaining business goals, social growth will come to a standstill. It must be understood that organizational objectives must admit within their purview a larger perspective to include community growth for sustainable development. Individuals trained to view community service as their responsibility throughout their lives, whatever their vocation in life may be, contribute a substantial progress in all aspects of development such as in the case of the Steel Authority of India Limited, particularly Bhilai Steel Plant. But the philosophy of individual and organizational social responsibility must be introduced at the onset of higher education. If the young minds can be motivated to participate in community welfare activities by stressing upon the sense of fulfillment, they will in all probability continue these activities during their professional career. Service Learning can be an effective tool for preparing scholars to turn individual service experience into an organizational service experience later.

Like Bhilai Steel Plant of SAIL, if every organization assigns a part of its resources towards taking up service programs solely aimed at non-profit achievements, the world will be undoubtedly a better place to live in. The authors of this paper are convinced that the `understanding and dedication to corporate social responsibility by Bhilai Steel Plant in India' is the outcome of an exemplary service learning experience and can work as a role model for other corporates of the world particularly in the developing nations by providing every one of its residents with the basic amenities needed by human beings.

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Efficacy of Engineering Intervention for Sustainable Development of Fisheries

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Abstract

During the last century, fishery sector made a significant development, mainly, with the advent of knowledge in fishery science in the developing countries. However, the progress is still not upto the mark and not comparable to that of the developed countries. In the nineteen eighties the need of engineering intervention for the development of the fishery sector of India was felt. Engineering knowledge can help in the site selection, planning and design of an aquacultural farm including its components such as sluice gates, dykes, canals etc. The hatchery and its components also require proper engineering design. In addition, engineering intervention can help in management of fish and prawn farms and hatcheries, design and operation of fishing crafts and gear for harvesting, preservation, processing, transport and marketing of fish and fishery products. Apart from this engineering knowledge can be useful for aeration systems, filtration systems, water management, breeding and hatchery systems, fishing gear and crafts, remote sensing and GIS applications in aquaculture, fish and feed processing and aquatic ecosystem and environment management. Engineering intervention needed for sustainability of fish production of the country is briefly presented in this paper.

Key Words: *Aquaculture, Engineering, Design, Farm, Sustainability.*

1. Introduction

Aquaculture is currently playing, and will continue to play a big part in boosting fish production and in meeting rising demand for fishery products. The role of aquaculture is becoming increasingly important in fish production for human nutrition and poverty alleviation in many rural areas. Aquaculture, in common with all other food production practices, is facing challenges for sustainable development. Most aqua-farmers are continuously pursuing ways and means of improving their production practices, to make them more efficient and cost-effective. There is significant potential for continued expansion and growth of aquaculture and culture-based fisheries through enhancement of inland fish production through integrated aquaculture-agriculture farming systems and integrated utilization of small and medium size water bodies. Additional opportunities/strategies for further development and increased food production include intensification of production, specialization of production, rehabilitation of existing production facilities, improved fisheries enhancement methods, diversification of production, combining on-farm and off-farm activities etc. The promotion of sustainable aquaculture development requires that “enabling environments”, in particular those aimed at ensuring continuing human resource development and capacity building are created and maintained. In that situation the development of aquaculture needs specialized human resources. The aquacultural system is a bioengineering system and the role of Aquacultural Engineers becomes vital in sustainable development of the system. As sustainable development of aquaculture is possible only by proper development of infrastructure it needs proper engineering input.

1.1 Global Aquaculture Scenario

Aquaculture has been the world's fastest growing food production system for the past decade. In the last three decades (1980–2010), world food fish production of aquaculture expanded by almost 12 times, at an average annual rate of 8.8 percent [1]. Aquaculture production increased from 12 million tons in 1986 to 60 million tons in 2010, valued at US$ 119 billion [1]. In 2010, about 40%

of the world's food fish supply was derived from aquaculture [1]. Global projections for future supplies from aquaculture production included estimates of 144.5 million tons by the year 2020 [2]. Aquaculture production continues to expand, however primarily in developing countries. Asia accounted for 89 percent of world aquaculture Production by volume in 2010, and this was dominated by the contribution of China, which accounted for more than 60 percent of global aquaculture production volume in 2010 [1]. With globally stagnating yields from capture fisheries and increasing demand for fish and fishery products, expectations for aquaculture to increase its contribution to the world's production of aquatic food are very high. Moreover, with more than 84% of the world's population expected to be living in developing countries [3], there is much hope that aquaculture will continue to strengthen its role in contributing to food security and poverty alleviation in many developing countries. In terms of volume, Asian aquaculture is dominated by fin fishes (64.6 percent), followed by molluscs (24.2 percent), crustaceans (9.7 percent) and miscellaneous species (1.5 percent). The share of non-fed species farmed in Asia was 35 percent (18.6 million tonnes) in 2010 compared to 50 percent in 1980 [1]. Coastal aquaculture is dominated by the production of aquatic plants (seaweeds) and molluscs. The production share of crustaceans and finfish is rather low (i.e. less than 15%), however their relative contributions to the value of total coastal aquaculture production is significant (i.e. 50%). Over the last three decades, the global aquatic systems have been subjected to massive pressures from fishing and other types of fishery resources exploitation with indicative fall of the marine capture production and an evident growth in aquaculture. Worldwide per capita fish consumption nearly doubled from about 9.9 kg in the 1960 to about 18.4 kg in 2009 [1]. Fish exports from developing countries have surpassed traditional export of crops such as sugar, beverages, and meat. According to FAO, net foreign exchange earnings from fisheries by low-income food-deficit countries rose from US$ 2.0 billion in 1990 to US$ 4.7 billion in 2010 [1]. At present, the fisheries sector in most developing countries continues to exhibit steady growth in production, consumption, and trade. Technological advances in aquaculture, changes in legal and institutional regimes and market demands have contributed to the changing structure of supply and demand patterns for fisheries products in both developing and developed countries.

1.2. Aquaculture Resources of India

India has a total coastline of 8118 km (including Andaman and Nicobar Islands and Lakshadweep Islands) [4]. The potential brackish water area available for aquaculture is approximately 1.2 million hectares out of which an area of approximately 157,400 hectares (14% of the total potential area) is under brackish water aquaculture [4]-[5]. The country has Inland water resources in terms of lakes and reservoirs of 2.09 million hectares and rivers and canals of 0.16 million kilometers. Apart from this fresh water earthen ponds of 2.25 Mha and abandoned paddy fields suitable for aquaculture of 2.3 Mha are available [4]-[5]. These aquaculture resources are either underutilized or need development for sustainable aquaculture.

2. Brief Background of Aquacultural Engineering

Aquacultural Engineering is a specialization of Agricultural and Food Engineering which deals with the design and development of Aquacultural Systems for marine and Freshwater including harvest and post harvest facilities. Aquacultural engineers are specialized in the following areas: a) planning, design, construction and maintenance of fish and prawn farms and hatcheries, b) different culture techniques and management of fish and prawn farms and hatcheries, c) design and operation of fishing crafts and gear for harvesting, d) preservation, processing, transport and marketing of fish and fishery products. Apart from this they are required to have research experience in one or more areas from the followings: 1) aquaculture system and management practices, 2) aeration systems, 3) f1ltration systems, 4) water management, 5) breeding and hatchery systems, 6) fishing gears and crafts, 7) remote sensing and GIS applications in aquaculture, 8) fish and feed processing and 9) aquatic ecosystem and environment.

On the basis of the recommendation of the National Commission, Ministry of Agriculture, Government of India formed a high power committee to give their recommendation for starting teaching and research in the field of Aquacultural Engineering in India. The Committee recommended establishment of Aquacultural Engineering discipline in the Agricultural Engineering Department at IIT, Kharagpur. In 1984, the discipline started functioning as a section in this Department.

2.1. Scientific Design of Farms

In the recent past Aquacultural Industry faced a lot of problems related to public nuisance, pollution and diseases due to improper site selection and design along with biological shortcomings. This reduced the pace of development of fast growing aquaculture industry in India. This type of problem can be tackled by proper site selection, scientific design of farms and proper management. An Aquacultural Engineer may play an important role in design and construction of such farms in compliance with the environment regulations.

A well designed fish farm will have a great impact on the quantity of production, cost of production, judicial use of water, energy requirement, maintenance requirement, ease of operation and overall pollution control. For sustainable development of aquaculture, it is essential to develop the farms in accordance with the environmental regulations. A scientific design of fish farm depends on proper site selection which involves the proper study of the soil, water source, quality of water, agro climatic condition, flood level, transport facilities, manpower, pollution level, competition from other industries, local tradition, political situations and other supporting facilities. Next important step is the scientific design of aquacultural farms. This involves design of peripheral dykes, partition dykes, sluice gates, supply channels, drainage channels and sedimentation & biofilter tanks (optional). Proper designs of these basic units are very important as they have a great impact on the life span of the project as well as economical operation of the farm. Based on the topographical condition of a site, a farm should be designed to reduce the cost of project as well as its economical operation. The selection of appropriate pumps for pump fed farms is very important as it has direct impacts on cost of production and energy saving. The cost of pipe lines and channels can be reduced by scientific design. Use of aerators is also becoming popular among the fish farmers as it improves the water quality and provides scope for intensification of culture. Selection of suitable aeration devices, estimation of requirements of number of aerators, their power and placement in the ponds are very important. A well designed farm will have minimum water loss and good water quality can be maintained in culture tanks to avoid disease problem.

2.2. Scientific Design of Hatcheries

The hatchery is the backbone of an aquaculture industry. Breeding of different species are done in the hatchery by creating natural breeding conditions. A healthy and disease free seed grows fast in culture system to yield better production. Thus quality of seed is a very important parameter for sustainable development of aquaculture. In India inbreeding is surfacing as a major problem for the hatchery industry. Therefore, brood stock management and germplasms maintenance have become very important for sustainable development. The design and construction of hatchery systems require sound technical skills. Very good skill is required for water quality management. Efficient and economical water filtration and disinfection system are needed for this [6]-[8]. A good design helps to produce healthy seed economically with ease of operation. The hatchery consists of water quality section, breeding section and larval rearing section. There should be good coordination between the sections. The aquacultural engineers can play significant role in design and construction of different hatcheries.

2.3. Design of Aerators and Aeration System

Next to feed, dissolved oxygen is probably the most important single variable regulating the production of fish in intensive aquaculture system. The culture system with low dissolved oxygen may not cause mortality directly to the fish life, but leads to the deterioration of water quality, which imparts stresses in fish body and in turn causes mortality. The supply of oxygen to the water body is essential to avoid the lethal action. The variations of rates of respiration, photosynthesis and diffusion process during different periods of the day change the dissolved oxygen level of pond water continuously. Ponds generally reach the minimum dissolved oxygen level during the mid-night or early morning. However, on cloudy days the dissolved oxygen concentration may reach the alarming level even during the daytime. Therefore, aeration is necessary to maintain adequate dissolved oxygen level in water bodies under culture.

The intensive fish culture system often needs the introduction of artificial aeration systems [9]. These systems vary from emergency aeration, operated only when the oxygen level drops to dangerous values through ordinary night-time aeration, to continually operating aeration systems in highly stocked ponds. The obvious role of aeration is to supply oxygen to fish. In addition, aeration of the water may affect a variety of other biological systems in the pond. In the biological treatment of wastewater, aeration is an important process employed to raise the dissolved oxygen (DO) level to allow aerobic bacteria to reduce biochemical oxygen demand of the effluent and thus to improve the water quality. The oxygen supplied must be at a rate sufficient to at least balance the rate of removal of the active biomass. Aerators are the devices used to supply oxygen to meet such demands [10].

Many different types of aerators such as paddle wheel, diffuser, propeller-aspirator-pumps, cascade etc are used in aquaculture. The performance testing of these aeration systems is also very important in selecting the design features to provide cost-effective yet efficient as aquaculture pond aerators. The most widely used surface aerator is the paddle wheel aerator [11]. It mainly consists of a number of paddle blades rotated in a vertical plane to spray large volumes of water into the atmosphere for oxygen transfer. The high velocity spray induces a turbulent flow on the surface creating a white water effect due to the large volume of entrapped air bubbles. This flow is also the driving force for convective mixing in the wastewater, which leads to uniform mixing of DO throughout the water. Extensive studies were conducted on the design and performance of floating electric paddle wheel aerator [11]-[18]. The design protocol developed by Moulick et al. [10] and [16] and Moulick and Mal [18] at IIT Kharagpur could very well be used for optimum design of a paddle wheel aerator based on the requirement of field oxygen transfer rate. At low hydraulic loading, packed column aerator functions efficiently and such an aerator was developed at IIT Kharagpur [19].

For small ponds, propeller-aspirator-pumps (1-3 hp) are found to be most suitable. The propeller-aspirator-pump aerator consists of a rotating, hollow shaft attached to a motor shaft. The submerged end of the rotating hollow shaft is fitted with an impeller which accelerates the water to a velocity high enough to cause a drop in pressure over the diffusing surface. Hence, atmospheric air is drawn into the hollow shaft. This air passes through a diffuser and enters the water as fine bubbles which are thoroughly mixed into the pond water by the turbulence created by the propeller. Due to its low weight, the propeller aerator can be installed easily, immediately and anywhere. Boyd and Martinson [20] worked on the design aspects of the propeller aerators and found that the maximum aeration efficiency occurs at a positional angle of 30^o. It has been found out that the aeration efficiency of propeller aerators increases up to 30 ppt of salinity [21]-[22]. Kumar et al. [23] developed optimum geometric and dynamic conditions for a propeller-aspirator-pump aerator (Nan Rong Hai Co. Ltd., Taiwan).

If site constraints and hydraulic conditions permit gravity flow, the least costly method to raise dissolved oxygen (DO) levels is with the use of gravity aeration. Gravity aeration can be performed using a simple weir, an inclined corrugated sheet or a stepped cascade. Stepped cascades have been used for a long time for the purpose of energy dissipation, aeration or removal of volatile organic components (VOC) particularly in case of dam spillway. The stepped cascade basically consists of a series of steps over which the water is allowed to flow as a thin film. During the fall of the water, bubbles rise up as air gets dragged in. Gas exchange occurs between the air in these bubbles and the water. Oxygen diffuses from the air into the water and helps to increase the DO content of the water. Stepped cascades could be used to reduce the dissolved nitrogen content. In the treatment of drinking water, cascade aeration is used for reoxygenation and removal of volatile organic components (VOC) such as methane and chlorine, dissolved iron and manganese, carbon dioxide, hydrogen sulphide, as well as the colour and tastes caused by volatile oils. At Indian Institute of

Technology (IIT) Kharagpur, Moulick et al. [24] developed a design protocol for a prototype rectangular stepped cascade system of typical height 3.0 m. The optimum number of steps, slope of the entire stepped cascade and hydraulic loading rate were found to be 14, 0.351 and 0.009 m^2/s respectively producing the maximum value of overall aeration efficiency of 0.90. Recently work has been carried out at IIT Kharagpur by Kumar et al. [25]-[26] on novel low cost cascade aeration system. The objectives have focused on standardizing the geometric parameters of the gravity aeration system and thereby develop an optimum dynamic condition and finally evaluate its performance in the field. In addition to aeration, inclusion of this system will potentially solve the problems of accumulation of toxic nitrogenous compounds as well as vertical stratification of the water body.

2.4. Development of Suitable Cage and Pen Culture

There is ample scope to utilize rivers, irrigation canals, lakes, reservoirs, marine and coastal water, back water, wetlands for cage and pen culture. The natural average production of these water bodies is very low. The productivity of these resources can be enhanced by using the above mentioned enclosure systems of culture. It has the advantages of intensive utilization of space, safety from predators; ease of harvest and culture of selected species. The design of cage and pen is to a large extent based on specific site condition and nature of water bodies. Locally available cheaper construction material may be utilized for development of pen and cage culture. The aquacultural engineers can help in the design and construction of site specific cage and pen culture system using local materials.

2.5. Integrated Aquaculture System

The concept of Integrated Aquaculture is gaining popularity nowadays as it is the system in which aquaculture is integrated with horticulture, agriculture, duckery, piggery, poultry, dairy etc. i.e. a combination of two or more enterprises. In addition to the production of fish for consumption or sale, integrated aquaculture has a variety of benefits for the farmers. The byproduct of one becomes the input for other. For example, poultry waste becomes fertilizer for fish pond. Mud from the bottom of fish ponds is also an organic mineral-rich fertilizer for agriculture and horticulture. The irrigation water of agriculture and horticulture is cycled through fish pond to produce fish and drained water which is rich in nitrogen is utilized for irrigation. The system is gaining popularity among the Indian farmers as they wish to have multiple products and good profit from their farms. An Aquacultural Engineer is equipped with the knowledge to design such projects with competence. At IIT Kharagpur, a very comprehensive study was taken up on integrated agri-aquaculture and very encouraging result was obtained [27]-[29].

2.6. Recirculating Aquaculture System

The recirculating aquaculture is the system to produce more fish with limited water, feed and space and at the same time have proper control over production. In this system intensive aquaculture is practised by recycling and renovating the water without affecting natural aquatic environment. This system is becoming commercially popular in situations of water scarcity and strict environment regulations. Recirculating aquaculture is economically viable and can be adopted for fish culture and ornamental fisheries. This system requires efficient design of culture tanks, mechanical filtration, biological filtration, aeration, and disinfection systems. Aquacultural engineers can contribute to the design and construction of the system as well as in research and further development works.

2.7. Fish feed

The quality of feed is a vital parameter for the growth of aquacultural species and water quality management. A good quality feed gives better feed conversion ratio and produces minimum adverse effect on water quality. The cost of aquaculture production mainly depends on the cost of feed as more than 60% of the production cost goes to feed only. For this purpose, high energy feed formulation using locally available cheaper materials are important. Apart from this the water stability and digestibility of the feed should be good as it has direct impact on water quality management. Extruder cooking and palletizing play important role in the quality of feed. Rout and Bandyopadhyay at IIT Kharagpur developed an efficient extruder [30].

2.8. Automatic Feeder

Automatic feeders are very important equipment for dispensing metered quantity of feed in the ponds at different time intervals. Use of automatic feeders reduces the wastage of feed, reduces manpower and helps in timely feeding. This gives good feed conversion ratio as well as helps to maintain water quality. Mal at IIT Kharagpur [31] developed an automatic feed dispenser using local materials and it works without any power source. Aquacultural engineers can design and construct these and other types of feeders.

2.9. Harvesting

Approximately fifty percent of total fish production comes from capture fisheries. At present, approximately 87% of the total landings are obtained from mechanized fleets. Infrastructure such as landing and berthing facilities has played a pivotal role in the development of capture fisheries. Now responsible fisheries have come up to regulate the sectors. This will be helpful for sustainable production and growth of natural resources. Aquacultural/Fishery engineers can contribute in the design and construction of fishing gears and gear accessories, development of energy efficient fishing gears and crafts, fishing techniques, modification of fishing gears and crafts, locating fishing zones etc. At IIT Kharagpur, scientists developed some efficient fishing crafts and gears [32]-[37].

2.10. Processing

Post harvest handling of fish is very important for increasing shelf life and retaining quality and nutritional values of fish and fish products. It requires development of energy efficient processing techniques and equipments. The processing sector has played a vital role in increasing the exports of marine products from the country. Modem processing units with state of the art facilities such as individual quick freezing and canning plants have been established and taken a form of organized industry. Aquacultural Engineers can contribute to the design and construction of fish handling system, grading and packing facilities, installation and operation of processing equipment, fish product development, research and development of processing equipment, packaging materials etc. Rao at IIT Kharagpur initiated some works on value addition of aquatic products [38].

3. Conclusion

Engineering intervention made in the developing countries during the last few decades and needed in the times to come for sustainable fish production, processing and value addition is described. Engineering knowledge can help in the site selection, planning and design of an aquacultural farm including its components such as sluice gates, dykes, canals etc. The hatchery and its components also require proper engineering design. In addition, engineering intervention can help in management of fish and prawn farms and hatcheries, design and operation of fishing crafts and gears for harvesting, preservation, processing, transport and marketing of fish and fishery products. Apart from this engineering knowledge can be useful for aeration systems, filtration systems, water management, remote sensing and GIS applications in aquaculture, fish and feed processing and aquatic ecosystem and environment management. Engineering intervention has been able to bring about much sustainability to the almost crashed coastal aquaculture of the mid-nineties.

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Embracing Social Media Technologies for Sustainable Digital Pedagogy

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Abstract

Digital nativity is rapidly replacing digital immigration as teaching and learning in today's classrooms, at all levels, (primary, secondary and tertiary), progressively enter the digital landscape. In this new landscape, Facebook, Twitter, MySpace, Bebo, Google Circles and other social media sites are rapidly becoming the preferred media of intellectual exchange among students rather than simply tools of recreational and conversational dialogue.

In this new landscape, institutional technophobia of social media is rapidly waning as there is an increasing realisation of the compelling need to restructure our pedagogical approaches so that they cater adequately to the current and future needs of our students.

One of the ways to meet students' demands in this digital landscape of the 21st century is through embedding social media technologies in standard constructivist pedagogy. This paper discusses the author's experiences of introducing the use of Google+. Discussion Circles in both an undergraduate and a doctoral degree program at one University in Australia. The results reveal that the application of social media as instructional and learning tools has significant potential to engage students' learning in more interesting, exciting and motivating ways that enable these technologies to provide sustainable development intellectually.

Keywords: *Embracing social media technologies, Digital landscape for 21st century learning, Digital technology for sustainable pedagogical development, Meeting 21st century students' learning needs, From constructivist to connectivist pedagogy.*

1. Introduction

The rationale for advocating the use of social media in teaching and learning is underpinned by foundational pedagogical theories from giants in the field that have withstood the test of time as bases for sound effective pedagogical practice. For example, Vygotsky [1] tells us that children learn best when they are given opportunity to construct their own understanding of concepts and issues through their interaction with others rather than working on their own. This theorisation extends beyond Piagetian constructivist thinking [2] because it puts emphasis on collaborative co-construction of knowledge. In his 5E Instructional Model, Bruner [3] alerts educators to the need to create quality learning environments characterised by giving children opportunity to Engage, Explore, Explain, Elaborate and Evaluate as they learn. Bloom [4] in his Revised Cognitive Taxonomy admonishes, among other things, that children's higher- order thinking is encouraged when they are given opportunity to create new ideas and objects. The warm embrace of social media for use in recreational and conversational discourses is proof positive that these technologies have potential to be preferred media of co-construction of knowledge. The ability of social media technologies to engage users and encourage them to explore new frontiers of knowledge is a resource whose potential is yet to be fully exploited by educational engineers and professional pedagogues.

2. Relevant Literature

Whereas social media technologies such as Facebook, Linkedin, Twitter, MySpace, and Instagram, to name a few, were initially conceptualised as tools for funny and humorous social connections outside the classroom [5], there are signs that they are increasingly being accepted for application in pedagogical practice. For example, a study by the Babson Survey Research Group and Pearson [6] found that 64.4 per cent of faculty used social media generally, and in particular, some 44.7 per cent used them for professional connections and 33.8 per cent use them for teaching. The same study also found that 41 per cent of faculty under the age of 35 used social media in their teaching. An additionally interesting finding was that penetration of social media into curriculum was reported to be higher in the Humanities and Arts, Professions and Applied Sciences as well as Social Sciences, compared to that in Natural Sciences, Mathematics and Computer Science. Across disciplines, the same study found that 88 per cent of faculty sourced video from online sources such as YouTube and used them in their teaching. These findings concur with those reported by Moran, Seaman and Tinti-Kane [7]. So it is clear that even though younger faculty have warmed up to the use of social media in their personal, professional and teaching interactions more than older faculty, social media are increasingly being embraced for use in pedagogical contexts by both digital natives of the information age as well as digital immigrants.

A study of the use of social media at the University of Massachusetts Dartmouth [8] found that 100 per cent of all colleges and Universities included in their study were using some form of social media. The same study found that in higher education Facebook was the most used social media tool and its use had grown rapidly from 61% in 2008 to 87% in 2010 and to 98% in 2011. The use of Twitter had increased from 59% in 2010 to 84% in 2011. That of Linkedin has increased from 16% in 2010 to 47% in 2011. The social media commonly used included Facebook, Twitter, Linkedin, Blogging and Message Boards.

Such penetration of social media into pedagogical practice and contexts is set to get deeper as barriers to the use of social media in the classroom and lecture theatre diminish. This was indeed demonstrated in the Pearson et al. study cited above [6] which found that the perception that social media are time-consuming was one of the barriers that had decreased the most.

As a matter of fact, other studies such as those conducted by educational technologist Schrock [9] have demonstrated the great time-saving potential of social media technologies if they are well designed for pedagogical use. Working with Bloom’s Revised Cognitive Taxonomy Schrock outlined a wide range of Android as well as iPad apps that could be used to readily support our teaching of Bloom’s Revised Taxonomy of Remembering, Understanding, Applying, Analysing, Evaluating and Creating. She identified six apps applicable to facilitate learning at each of these different cognitive levels as illustrated in Figure 1, for the Android and in Figure 2 for the iPad. For the low, thinking level of Remembering, Schrock listed apps for simple recalling, listing, bookmarking, searching, mind-mapping and word processing. As we move towards higher-order thinking involving Understanding, Schrock outlined apps that can be used for express categorisation, annotating, tweeting, blogging, subscribing and explaining. As she raised the bar to Applying, she listed apps that can be used for interviewing, simulating, demonstrating, presenting, editing and illustrating. At the fourth cognitive order of Analysing, she listed apps that are very efficient in outlining, structuring, organising, surveying, demonstrating and mashing. For Evaluating, the Android apps that Schrock highlighted included the Google sourced moderating g+, conferencing, networking, posting, collaborating and critiquing. At the highest learning level of Creating, Schrock outlined apps that can be used in the classroom and tutorial room for storytelling, video editing, videocasting, mixing, animating and podcasting. The common icons for all these apps are illustrated in Figure 1 for the Android and in Figure 2 for the iPad.

If we appreciate that the digital generation of children and students in our classrooms and lectures today spend most of their time online, then it makes a lot of good sense for our educational engineering efforts to find ways that create a coincidence of wants between what we want them to learn and how they prefer to learn. This educational engineering double coincidence of wants is simply good logic which makes supply meet demand. In bridging such a gap, educational engineering will help professional pedagogues to address the issues that Jukes, McCain and Crockett [10] refer to as children's digital experiences that are rewiring children's cognitive processes.

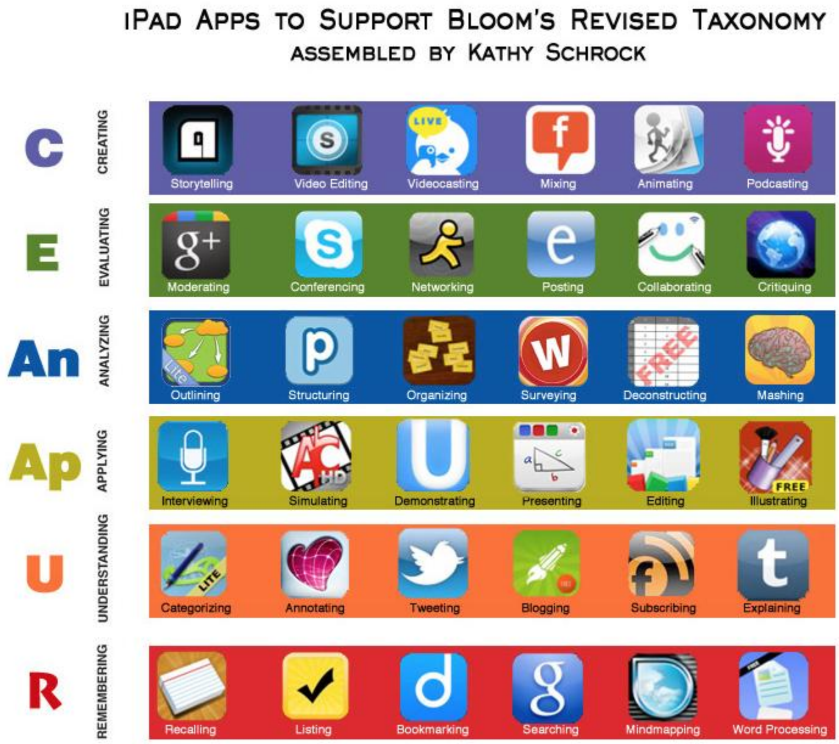

Figure 1: Kathy Schrock's illustration of applying Bloom's Taxonomy using Android Apps

Figure 2: Kathy Schrock's illustration of applying Bloom's Taxonomy using iPad Apps

3. Methodology for Educational Engineering with Google+ Discussion Circles

This paper is drawn from the author's experiences of two attempts, to engineer or embed social media technologies in the design and teaching of two units. The first attempt involved a group of 15 students enrolled in a doctoral degree unit. The second involved a much larger cohort of 258 undergraduate students in their second year of a Bachelor in Education degree at one University in Australia. The doctoral students' unit was offered in a completely online mode to external students. Most of the doctoral students were employed in Australian schools or other institutions of learning where they occupied positions in middle level management such as Head Teachers in schools, Coordinators or Assistants to Principals. A few of these students resided in overseas countries that included Saudi Arabia and South Africa. The online mode suited their busy work schedules quite well because of the flexible design which facilitated their engagement with the unit at times that suited them rather than regimented by lecture schedules.

Of the 258 undergraduate students, 98 were on-campus students and 160 were off-campus and received their instruction and learning materials online. Like all students of this University, the three cohorts (the doctoral cohort, the on-campus undergraduate cohort and the external undergraduate cohort) had access to the main Learning Management System (LMS) called Moodle.

Before the introduction of Google+ Discussion Circles to any of the cohorts, all cohorts relied on posts in Moodle Forums for their discussion. They had opportunities to design wikis and to textually chat within their groups. For the on-campus cohort, discussions in the Moodle Forums were not essential since they had opportunity to discuss concepts and issues in their tutorials on-campus. It was the online cohorts, both doctoral and undergraduates, that really needed the opportunity to dialogue with their peers in the online environment.

As I monitored the posts in the Moodle Forums I noted a need among the external students for greater opportunities to interact with one another. In an attempt to meet such demand for increased students' interaction, I decided to embed into these two units, selected social media technologies, namely Google+ Discussion Circles (GDC), eFoliospaces and YouTube. While trying to meet this demand, I also wanted to investigate several questions. Firstly, can we engineer or design links between Moodle LMS and GDC? Secondly, are these social media tools ready to be embedded in formal constructivist pedagogy? How would students react to the invitation to engage in eLearning via GDC? And finally, does the introduction of GDC facilitate and/or increase students' engagement with their learning?

3.1. Design to Maximise Students' Engagement

The design engineered was to enrich and maximise peer-to-peer learning among the students through asynchronous, virtual conversations using social media technologies that are not yet widely used in pedagogical practice. For each cohort, a Peer Learning Network (PLN) was formed to serve as an-asynchronous round table. Because the doctoral cohort was relatively small, the 15 of them formed one PLN. The external undergraduates formed 16 PLNs each comprising 10 students. Each PLN was nucleated around a GDC. Members of each PLN also shared eFoliospaces and YouTube resources openly sourced from the Internet. PLN members were free to embed YouTube resources, such as video clips into their GDC and eFoliospaces. Members of each PLN could post to the stream and comment on their peers' contributions and resources while adding their own. They could take their own photos or shoot their own videos and add these to the stream.

The whole process was set up to start in a Moodle Discussion Forum because all students had access to this in the University's LMS. Instructions were given to them in Moodle to introduce themselves to their peers and open a gmail.com account and share the gmail address with their peers. This step was included so as to maximise students' interactions with their peers, not only while they were students at the University and therefore had access to the University's email provider, but also later on after they would have left the University. The gmail account remains with them whereas the University email account ceases when they complete their studies. Instructions were also given to them in Moodle as to how to initiate a GDC. Any member of a PLN could initiate the GDC and invite their peers using their gmail addresses. Clear instructions were given so that students operated within the private rather than the public domains of Google. Instructions were also given on how to design a personal website using eFoliospaces and advise their PLN members of the URL for their eFoliospaces. Each of the doctoral students had to complete three literature critiques of set readings available in eReserve of the University Library and create a link via the GDC to their literature critiques so that their PLN members could review and comment on their critiques. The undergraduates were given a weekly topic for discussion, in line with the lecture for the corresponding week. Any member of any PLN was free to invite anyone they wanted to join their GDC and subscribe to the stream. Strict instructions were given such that the people invited had to keep their posts to the academic topic for conversation. Mere social chatting was not allowed. There was opportunity to exclude people from the GDC so that they could not follow or add to the stream if they did not uphold the prescribed academic rules of engagement.

4. Results

While the findings discussed here are not the result of a full-fledged study but simply a sharing of personal experiences, they shed some light on the potential for carefully engineered social media technologies to be applied in teaching in a manner that extends our pedagogical practice beyond orthodoxy constructivism to digital connectivism.

Table 1: Comparison of students' engagement under the old Moodle and New GDC Technologies

	Participation under Traditional **Moodle LMS – Technology**		Participation under **New GDC – Technology**	
Group/PLN	Initial Group Participants	Final Group Participants	Initial PLN Participants	Final PLN Participants
1	10	10	10	46
2	10	10	10	72
3	9	9	10	51
4	10	10	10	48
5	8	8	10	62
6	10	10	10	38
7	10	10	10	49
8	10	10	10	56
9	9	9	10	34
10	10	10	10	52
11	10	10	10	28
12	10	10	10	33
13	9	9	10	28
14	10	10	10	53
15	10	10	10	62
16	8	8	8	48
Totals	153	153	158	760
Percentage participation		**100%**		**481%**

4.1 Discussion

What emerged very clearly, and as illustrated in Table 1, was that the introduction of GDC as social media technologies, reduced the tyranny of distance and enhanced social presence as students participated in discussions in their virtual classrooms founded on PLNs. Their engagement through PLNs was more frequent and absolutely greater than that under the old Moodle Learning Management System (LMS). For example, whereas under the old Moodle LMS the final number of participants was 100% that under the new GDC technologies was 481%. This needs some brief explanation. Under the old system, every student participated and as this was a mandated requirement, there was a 100% response. That is, every student had to post a comment within their group to contribute to the discussion. However, under the new

GDC technologies, each student was asked to participate in the discussions but also given the opportunity to invite other people from outside their group of ten to participate in the GDC discussions. As a result of this design, instead of the ten members of each PLN, the PLNs increased their membership to those shown in the last right-hand-side column of Table 1. Thus, whereas under Moodle each Group of 10 had 10 participants, under the GDCs, group 1 of ten ended up with 46 participants, group 2 grew to 72; group 3 with 51 and so on as illustrated in Table 1. This is all the more interesting when you consider that group participation under the old Moodle LMS was mandated, but the invitation of others under the new GDC technologies was voluntary.

The results shown in Table 1 are very encouraging for application of GDC social media technologies in pedagogy but what is even more interesting, though not discussed here for shortage of space, and because these results are rather tentative, is that the frequencies of posts among the GDC PLN members were much more frequent than those among the old Moodle groups. Moreover, the comments students posted in the GDC PLNs indicated that they appeared not to see themselves as individual learners, or learning in isolation, but in PLNs that were supportive of each other. They did not appear to be competitive with each other, but collaboratively seeking to engage with the concepts and issues being discussed rather trying to outsmart each other. For students enrolled in the online, distance education mode to be expressing such feelings, lends a lot of support to and shows potential merit in learning engineering which embeds interactive, interconnecting social media technologies into pedagogical practice.

It was very interesting and encouraging, to see how students sourced and shared stimulus materials with members of their PLNs. Many of the comments in the streams reflected peer mentoring and guidance for each other. The extent to which students shot videos of their own workplaces and shared these with their PLNs indicated a move towards self-regulated learning based on interest, motivation and personal drive. The comments made on other students' posts reflected aspects of peer feedback and peer assessment that was given freely and at times unreservedly.

It was clear from monitoring the streams in the GDC that students' construction of knowledge was moving from the orthodoxy cognitive constructivist thinking that emphasizes Piagetian personal construction of knowledge not only towards Vygotsky's social constructivism but more importantly towards digital connectivist pedagogy. By connectivist pedagogy I mean what Castells [11] characterized as learning that focuses on building and maintaining networked connections that are current and flexible. An underlying assumption of connectivism as envisaged by Castells [11] and also discussed by Anderson and Dron [12, p. 87] that I found to be very evident among my students was that "information is plentiful and that the learner's role is not to memorise or even understand everything, but to have the capacity to find and apply knowledge when and where it is needed". Students' apparent enthusiasm to engage in GDC (apparently more so than in Moodle Forums) appears to be very consistent with what Kanuka and Anderson [13] characterize as knowledge acquisition that needs to be subject to social discussion, validation and application in real world contexts. The fact that students took initiative to invite their friends outside of the University to participate in their academic discourses in the GDC reflected their sense of self-efficacy and personal competence in utilizing PLN-based cognitive skills. These skills appeared to fall within Bloom's [14] higher-order thinking skills of Applying, Analyzing, Evaluating and even Creating. Students' critiques of readings from the eReserve, designing eFoliospaces and sharing their Urls with their peers demonstrated high levels of Engagement, ability to Explore, Explain, Elaborate and Evaluate that appears to be consistent with Bruner's [3] 5E Instructional Model.

5. Conclusion

The enthusiasm and level of engagement demonstrated by students' contributions to the discourses in the GDC suggests that there is a compelling need for educational designers or engineers to redesign their LMS and resources so that they meet the demand for learning using digital tools that have become widely embraced by children of this digital age. Such educational engineering will enable teachers and lecturers of today and the future to deal with the realities of learning and teaching in the current and future, high-tech, digital world. If educational designers or engineers do not embed social media technologies into curricula, their educational offering will reflect a mismatch between supply for and demand of learning by digital learners.

The greater engagement and creativity demonstrated by the participation in GDC, eFoliospaces and YouTube embedment by both the doctoral and undergraduate cohorts seem to suggest that these technologies are more effective in engaging students than the traditional tools based on orthodox textologies or simple Web 2.0 technologies including forums and wikis in LMS such as Moodle, Blackboard or Sakai. Of course, caution needs to be exercised when students are given the opportunity to invite whoever they want and from wherever in the world-wide-web those invitees might source materials to be shared in the GDC and wherever in the real world they might reside. But it would appear that the advantages created for our students as we educate them in the world rather than a classroom far outweigh the dangers or risks that might be real or perceived. And it is the minimisation of potential risks that calls for ingenious educational engineering so that social media technologies such as those experimented with in the present experience are given higher digital tariff walls to protect users.

The days when utilisation of social media tools was an after school pass-time should be relegated to archives of educational institutions. As Jukes, McCain and Crockett [10] argue, if educators are to be true professionals, driven by the concern for their present and future students, they have no choice but to adapt to the new contexts in which they and their students live. Failure to do so will deny their students the opportunity to engage and to explore more deeply, concepts ideas and strategies that they are exposed to. It would be unwise for educators to be aware that the demand for education has changed and yet continue to supply education in the same old ways. Such an incongruous supply and demand relationship would fail to cater to the needs of children of the digital era and turn out graduates that would be ill equipped to contribute to society in the digital world. Perhaps the most convincing comment to conclude this sharing of experiences can again be drawn from Jukes, McCain and Crockett [10, p. 5] who succinctly articulate that, "… unless.. adult parents, teachers, administrators .. and politicians … counterbalance their old nondigital life experiences with new digital experiences, (they) will have catastrophic consequences for education". This is where educational engineering has a vital role to play in enabling teachers and lecturers, and any other professional pedagogues, to meet this apparent imperative for pedagogical change, so as to ensure an efficient and effective transition to a sustainable digital pedagogy for our children today and tomorrow.

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Presenter: The paper is presented by Charles Kivunja

Enhancing Citizen Participation in South African e-Government Through Trust

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Abstract

Many governments around the world, including South Africa, are spending millions of rands on improving their e-Government services to allow citizens to interact with government more freely than before. Although the evolution of e-Government started during the early 1990s, it has not achieved the same success in terms of citizen participation as e-commerce [1]. *While some countries have reported success with implementing these services, including Canada, the United States and Taiwan, the participation rate in e-Government services in South Africa has remained relatively low. This has been attributed to an inherent lack of trust, inadequate resources and other external factors.*

An important condition for effective cooperation between individuals, groups and organisations (including government) and their systems, is the element of trust [2]. *Since this study is concerned with citizen interaction with e-Government, the trust discussed is that of citizens in e-Government and the influence of this trust on their participation. A key inhibitor of e-Government use is citizen scepticism with regards to the security of any personal information divulged as a result of their interactions with the site. Thus, for citizens to participate they need to trust that their information will be safeguarded.*

In addition, a poor government image and a perceived lack of transparency in the South African government are contributing factors to low participation. According to the e-Government Readiness Index, which determines the capability and motivation of countries to use e-Government for development, South Africa is considered ready for e-Government. However, actual citizen participation in e-Government remains low. This indicates a need to make citizen awareness, of both the availability of the services and on security mechanisms in place to safeguard information, a priority in order to ensure participation.

Thus, this paper sets out to investigate the lack of trust in e-Government services, the effect on participation and propose a model for enhancing trust and participation in e-Government, specifically within a South African context. This e-Government Trust model considers the factors that affect citizen trust (and therefore participation), namely ability, integrity, security and data privacy, and proposes infrastructure, user experience, education and awareness as elements required to increase participation. These elements are derived from an extensive literature review of studies in similar, developing economies. This model can be used to identify areas that need to be addressed in order to ensure that trust and citizen participation in e-Government is achieved.

Keywords: *e-Government, Participation, Trust.*

1. Introduction

E-government has been conceived as the use of information technology in government for the better supply of public services and the advancement of democratic values [3]. In addition, e-government is viewed as an aspect governments could use to increase trust and improve the citizens' perceptions of government [4]. As with e-commerce, the participants in e-government have to be able to trust the vendor (the government) offering the service. Trust has long been viewed as playing a significant role in the development of interdependent relationships in online transactions such as those in an e-Government context. Further to this, trust is an important catalyst in the formation of dependence between individuals and governments in online participation [5].

While South Africa is considered to be ready to adopt e-Government, citizen participation has remained low. Reasons for this low participation include: trust, infrastructure and environmental factors. The lack of trust in e-Government that hinders successful citizen participation is widely recognised and highlights the significance of this research. This study sets out to explore the most important strategic trust issues around e-Government. It will investigate and consider strategies that can be used to enhance the levels of trust, and consequently participation, in e-Government. Thus, this paper proposes a model to establish a means of enhancing trust and participation in e-Government services based on relevant literature in these areas of studies.

This paper first outlines the problem to be investigated and the method followed for the purposes of this paper. This is followed by a theoretical discussion which reviews aspects affecting trust and participation that are relevant in this context. This culminates in the proposal of an e-Government Trust-Participation Model.

2. The Problem – Trust Inhibiting Participation in e-Government

An important condition for effective cooperation between individuals, groups and organisations (including government) and their systems, is the element of trust [2]. Since this study is concerned with citizen interaction with e-Government, the trust discussed is that of citizens in e-Government and the influence of this trust on their participation. A key inhibitor of e-Government use is citizen scepticism with regards to the security of any personal information divulged as a result of their interactions with the site. Thus, for citizens to participate they need to trust that their information will be safeguarded. In addition, a poor government image and a perceived lack of transparency in the South African government are contributing factors to low participation.

According to the e-Government Readiness Index, which determines the capability and motivation of countries to use e-Government for development, South Africa is considered ready for e-Government. However, actual citizen participation in e-Government remains low. This indicates a need to make citizen awareness, of both the availability of the services and on security mechanisms in place to safeguard information, a priority in order to ensure participation.

3. The Method

Existing e-Government research largely focuses on infrastructure barriers to e-Government success in South Africa. Usability and citizen-based barriers to use are rarely (if ever) considered. As the ultimate use of the e-Government services relies on the citizen’s confidence and willingness to participate in the service, these factors are an important contribution of this research paper.

This study therefore reviewed the recent and available literature, and academic and professional perspectives from various media on trust in e-Government. The media reviewed included printed media (such as books and journals) and online media in the form of electronic journals and industry white papers. Through this review, the effects of trust on e-Government participation were investigated, and a proposed model developed.

4. Theoretical Background: Trust, Participation and e-Government

Trust is a fundamental aspect that must exist between the government and the public in order for e-government to be successful in South Africa. It is suggested that trust in government has been declining steadily over the last four decades [6]. This has been mainly due to poor service delivery and untrustworthy governments. As part of the solution to this problem, information technology (IT) helps governments to improve service delivery to citizens[7]. The authors add that with e-government, service delivery will be quicker, more cost-efficient and effective. The sections that follow define trust in order to provide a foundation for the discussion of factors affecting trust and participation that follow.

4.1. Defining Trust

Trust is recognised in literature as a complicated concept that is a constant feature in many fields including social psychology, economics, and sociology [8]. This makes it difficult to define. It is often concluded that there is no universally accepted definition of trust [2]. A definition related to trust in e-government states that trust is a belief, expectancy or a feeling which is deeply rooted in a person's psychological upbringing [8]. Trust is also seen as "an expectancy that the promise of an individual or group can be relied upon" [9]. It is similarly defined as the expectancy by one person or a group of ethically justifiable behaviour on the part of the other group or individual [10]. For this paper, the preferred definition of trust is that which defines trust as being determined by the ability, benevolence and integrity of the trustor (in this case the South African government) [11]. These constructs are an important consideration for the model proposed in this paper.

Having defined trust, it is clear that trust in e-government has a significant impact on the participation of citizens in e-government. Trust or the lack thereof, is cited as the main reason for reluctance of citizens to adopt e-government [9]. The authors further state that e-government has huge potential to improve government services, but this potential will only be realised if the e-government is believed to be trustworthy by the citizens. Therefore improving trust in e-government should improve participation. The factors which determine the level of trust citizens place in e-government are described in the next section.

4.2. Factors Affecting Trust in E-Government

The previous section defined trust as an individual's expression of confidence in anothers' intentions and motives. The definition indicates that the trusting individual must have an opinion about the trusted individual's character and reputation. Therefore, in order for citizens to be able to trust the government, they should have a good image of the government, thus the government image plays a role in persuading citizens to trust and participate in e-government services.

The challenge of the 21st century is for governments to transform themselves to engage citizens in democratic activities and to improve their trust [12]. For citizens, placing trust in e-government entails making themselves vulnerable in terms of their personal information and how secure that information will be. It is believed that trust in e-government is highly dependent on the government facilities keeping the citizens information private [9]. This means that the government should be able to guarantee citizens that their information will be kept safe and that it will be used for the purposes that it is meant for.

Most scholars of e-government agree that trust in a government is an important determinant of public action and cooperation [6]. The South African government has not been without scandal and embarrassment that has tarnished its image to its citizens and the world at large. Trust in the government is almost synonymous with the amount of transparency the government shows to its citizens. e-Government is a way for the government to be more open and transparent and in doing so reinforce democratic participation [13]. This will lead to the government being more service oriented, providing personalised and very inclusive services to the citizens of the country, and giving value for the taxpayers' money.

It is believed that the internet enables citizens and government personnel to have instant access to information available about the government and its activities [14]. This undoubtedly increases the transparency of the government to it citizens and therefore should increase their trust and participation in e-government services. e-Government promises to enhance delivery of many types of public services, those include online transactions and the dissemination of information about the operations of the government [4]. Therefore e-government can improve communication between the government and citizens through the websites which would enable citizens to participate directly in government decision making. Additionally, the internet provides a flexible and convenient interface where the citizens can have access to the government all year round [4]. If the citizens are afforded these rights they will have a better picture of what the government is doing and hence will understand what goes on. That will improve their trust in e-government and increase their participation.

IT is increasingly being used to mediate between organisations [2]. It goes without saying that the technology and resources must be available for successful implementation. There are resources that the public sector needs to possess as well those that the citizens themselves have to have to ensure participation in e-government. Additional factors to improve participation are discussed in the section that follows.

4.3. Improving Participation in E-Government

While several factors are identified in literature which can ensure that participation in e-government improves, the discussion that follows is limited to infrastructure, education, awareness and user experience. There are numerous considerations in terms of the required infrastructure that need attention for the successful implementation of e-government. The government needs to create the perfect environment for e-government to thrive in this country. E-Government is accessed through various technology platforms including websites available via personal computers, mobile phones, call centres, digital televisions and public information kiosks. Some of these resources are readily available in South Africa and therefore could be used to participate in e-government. The government needs to have a strong presence in the ICT industry and invest in the technology that makes e-government possible.

Application service providers (ASP) are needed to overcome the burden of offering e-government services to citizens [15]. Governments find it difficult to compete with the private sector in finding and retaining IT talent because they are not as financially sound as the private companies which specialise in IT. Application software providers are able to offer applications at reduced costs than a company or government could provide for themselves internally.

The technology alone is not sufficient to ensure the success of e-government without the human element to support it. The transition to e-government has challenges that go beyond technology. New forms of skill sets, new forms of leadership are also prevalent in this transition. Employees of government have to acquire new skill sets to be able to work in the government. In addition, considering digital divide issues which are prevalent in South Africa, providing equal access to the platform requires numerous interventions aimed at equipping all citizens with the necessary skills. These skills and digital divide issues contribute to a negative user experience which impacts negatively on the participation rate in e-Government.

Education is very critical in the adoption and improved participation in e-government. Highly educated people are more inclined to join and trust e-government services and this is partly because they are financially better off [16]. This is believed to be due to their superior skills, resources and tendencies that were imparted to them at home and at school[16]. A positive relationship between the individuals' level of income and level of education and participation in e-commerce has been noted in previous research [17]. They state that people with higher levels of income are likely to have more web experience and participate in the internet. Therefore the higher the level of education citizens possess the higher their trust is in e-government.

Once the infrastructure is available for use then the citizens must be aware of this availability. If the targeted citizens have no idea if that the e-government services exist, no one will participate in them. The success of e-government is dependent on making connections between individuals and departments via IT [13]. The people who are meant to use the e-government services need to be aware that the services are available. Thus, it is safe to deduce that the more aware the citizens are about e-government the better the participation.

Based on the trust and participation factors discussed above, an e-Government Trust-Participation Model is proposed in the section that follows. The creation of this model should help the government understand the factors that influence trust and participation in e-government.

5. An e-Government Trust-Participation Model

The e-Government Trust-Participation Model is based on the assumption that trust is an antecedent from which participation in e-government is based. Only after people trust the e-government, will they willingly participate in e-government. The factors identified in the previous sections which impact on trust in the e-Government platform are:

1. *Ability*: This is defined as the skills, competencies and characteristics that ensure the trustee has influence in the relationship [18]. In the e-government context this is the perceived ability of the South African government to carry out the required tasks in a competent manner.
2. *Integrity*: This is defined as a perception that the trustee prescribes to the principles that the trustor finds acceptable [18]. In the e-government context, this refers to the reputation of the South African government, which negatively impacts on the citizen trust levels.
3. *Security*: This is the perceived risk of participating in e-government services where a citizen may not be certain that adequate security mechanisms are in place to ensure they are not disadvantaged while using the service.
4. *Data Privacy*: This is the risk of information provided while using e-government services being leaked, or made available publicly. This is a key concern for users (and potential users of e-government services).

These trust factors are depicted in the first block of the model (Figure 1). Once the existence of these trust issues is acknowledged, four interventions are proposed in order to mitigate these issues:

1. *Infrastructure:* This refers to the government providing access to e-government services to all citizens on a variety of platforms. The key consideration here is to ensure equal access amongst all stakeholders.
2. *User Experience:* This refers to ensuring e-government services are designed in such a way that any citizen will derive a satisfactory experience when making use of it. It is particularly important that this type of intervention considers the digital divide issues which have plagued South Africa in the past.
3. *Education:* This refers to providing education programs to assist citizens in their use of the e-government services. This education should focus on those citizens who have not had access to formal computing education.
4. *Awareness:* This refers to embarking on an awareness campaign to sensitize citizens to the range of e-government services that are available to them and how these can positively impact on their lives.

These participation interventions are depicted in the second block of the model. Once the necessary interventions have been enforced, it is necessary to assess the impact they have had on the citizen's willingness to participate. As this is a continuous process of overcoming trust issues in e-government, the feedback loop is necessary in this model, so that citizen trust is reassessed and the process is then repeated.

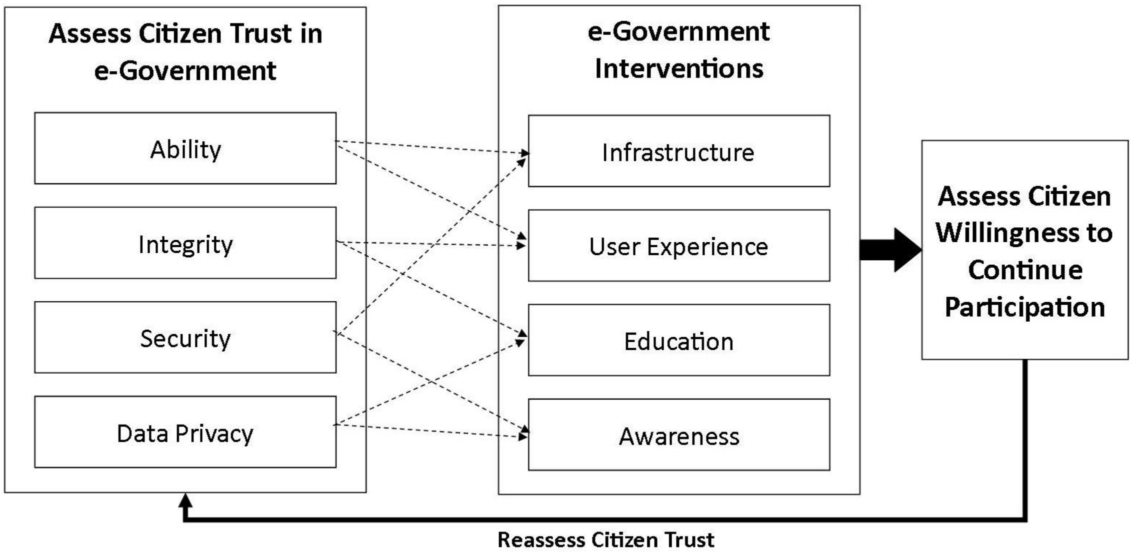

Figure 1 Proposed e-Government Trust-Participation Model

6. Conclusion

This paper investigated factors which affect trust and participation in e-government services. A literature survey was conducted which provided the foundation for the proposed e-Government Trust-Participation Model. This Model proposes four factors which affect trust, namely ability, integrity, security and data privacy. These trust factors can be mitigated by infrastructure, user experience, education and awareness.

Further research conducted into enhancing citizen trust and participation in e-government will empirically test and refine this model to ensure its applicability within the South African e-government context. The model suggested in this paper can also be expanded into a framework to assist government in improving its e-government offerings.

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