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140 AN ACADEMIC'S TOOLKIT FOR INNOVATIVE PROJECT REPORTING USING AUDIO VISUAL MEDIA

Peter Willmot[1], Mike Bramhall[2] & Keith Radley[3]

1 Loughborough University, P.Willmot@Lboro.ac.uk
2 Sheffield Hallam University, M.D.Bramhall@shu.ac.uk
3 Author 3 Breakthrough media Ltd., breakthroughkeith@gmail.com

ABSTRACT

The paper introduces a novel method of injecting additional motivation to team projects. Teams of students, engaged in a variety of different assignments are encouraged to learn while creating their own audio-visual media; they are required to prepare and edit a short video documentary as a replacement for the more conventional written or oral report. Using survey data, collected over several years at two separate UK universities, the authors provide evidence that this medium generates much needed engagement, help teams to bond and promotes a deeper understanding of the subject matter. An additional benefit is that the assessment process is considerably less tiresome for the academics. There appears to be vast potential for transferability of this method to many different applications, disciplines and age groups, but while the idea may sound attractive to many lecturers, it marks a significant departure from the norm. The authors have, therefore, created an easily accessible 'toolkit' resource that focuses on issues faced by a new adopter based on their own experience and on feedback from staff and students who participated in the pilot projects. The 'toolkit' incorporates appropriate resources, including teaching and assessment materials, with example projects taken from the science and engineering subject areas.

Keywords: Video, Engagement, Teamwork.

1 INTRODUCTION

The video documentary is a very widely used and effective medium through which investigative journalism is disseminated on all kinds of topics. Such works present information in a way that is easily accessible and often entertaining. Video reporting has now proven to be a surprisingly useful innovation in engineering education where it has been successfully adopted by two UK universities as part of a programme to enhance student engagement and reduce wastage; an issue that is currently of great interest in the sector.

There is already a large body of knowledge about student engagement but, according to Tinto [1], most institutions are yet to translate what we know into forms of action that improve persistence and retention. It is known that "…the adoption of teaching approaches that actively engage students from the outset" can enhance the student experience [2]. These ideas are founded in constructivist learning theory where learners are invited to construct knowledge for themselves, become actively involved and learn how to learn while they are learning. Innovators, looking for ways to improve motivation, therefore, tend to focus on self-directed learning through the use of projects, competitions and teamwork [3], also the central idea of a learner-led curriculum that is increasingly made possible through the appropriate use of technology.

In this paradigm, student teams, engaged in a research project prepare and edit a short video documentary as a direct replacement for the more conventional written or oral report and in doing so, help to build their own autonomy as effective learners and develop valuable employability skills. The potential for transferring this idea across disciplines is obvious, but for many lecturers, though the idea may sound attractive, it is a leap into the unknown. Having recently completed a 12-month Royal Academy of Engineering (HE-STEM) project to prepare an easily accessible 'toolkit' for lecturers that addresses the issues faced by a new adopter, the authors are now in a position to describe their own case studies and provide help and advice to others who may wish to adopt the idea.

2 ENHANCING TEAM PROJECTS

2.1 Methodology

Themed student-centred team projects have been widely used in STEM (Science, Technology, Engineering and Mathematics) subjects as a vehicle for developing desirable transferable skills and can now be found in all parts of many forward-thinking engineering degrees. The 'Engage' Engineering Project[4] confirmed that these strategies improve motivation, enhance learning, improve performance and retention rates and increase student commitment to engineering careers. Nevertheless, a poorly constructed project assignment can fail to result in either improved skills or deep learning, and can be seen as simply a chore by the participants. Team projects, for example, where the individuals simply divide the task up by the number of team members, perform individual internet research and subsequently paste together their findings as a single document provide little intrinsic motivation, little long-term knowledge acquisition and a false basis for skills development.

FIGURE 1. *A student presenter, on location.*

The video reporting method enhances a project and proactively addresses these deficiencies. Research projects traditionally require students to submit a substantial written report and possibly an oral presentation. However, assuming these key skills are adequately addressed elsewhere in the programme, it is reasonable to suggest that the assessment method for one or more assignments might be different; an additional written report is hardly going to motivate students. A small team at Sheffield Hallam university provided the initial inspiration to further trial and adapt this new method at Loughborough, when they presented their initial ideas at EE2008 [5]. They claimed that the video report added realism and aided communication skills development; that students were motivated by this methodology and that it enhanced achievement and learner autonomy although, at that time, the claims were largely anecdotal.

Essentially, a research task is set in the familiar way, and can presumably be set on any theme, but instead of the usual written and oral report, teams are required to report their findings in the form of a documentary video file. Students are provided with suitable, user-friendly filming equipment (Pre and post production) they are also encouraged to conduct research and seek out appropriate locations and props to support their reports. Clearly, it makes sense to use this method for topics that have the potential for location filming or to show moving objects but the method has been successfully exported into other, non-STEM areas such as nursing and history. The creative opportunities open up and the need to work as a team becomes paramount. Certainly, we have discovered that students like to be challenged and generally respond well. Their ability to deal with the audio-visual technology, without much training, has consistently exceeded expectations.

Video reports can be incorporated into new or existing modules to form part of the coursework assessment. Existing examples have catered for student cohorts up to 150 where the assignment accounts for typically 20-30% of the modular credit. Assignments, incorporating video reporting at Loughborough and Sheffield vary in length, and have been set with both first and final year engineering and materials science cohorts. Various formats have been tried and these are described in some detail three separate short case studies, included in the 'toolkit', which will be available, free of charge, at the conference or by contacting the authors.

2.2 Reported Outcomes and Feedback

There is strong evidence that film production adds to the challenge and enjoyment of assignments, which consequently enhances motivation and leads to high quality work. This first became obvious to staff at both institutions when viewing the students' video creations, the quality of which generally exceeded expectations. Most of the videos are particularly strong visual records of close teamwork in action and the toolkit contains examples of student work that clearly illustrate this.

The benefits of this approach have been thoroughly evaluated through focus groups and online surveys. The focus group analysis was presented at SEFI-2011 as part of World Engineering Education Flash week [6]. The focus group discussions were captured on video, which has enabled a selection of short clips, organised in themes, to be presented on a DVD which is included in the toolkit, so that enquiring lecturers can experience the staff and student voice at first hand. The survey provided much needed qualitative feedback which was used to develop the process. A small selection of the online results is displayed in figure-2. The charts, which are largely self-explanatory, present feedback on three first-year groups from Loughborough University (LU) and one final-year group from Sheffield Hallam University (SHU) with a total of 198 individual responses. Aside from the expected improvements in key transferable skills, around 90% of respondents consistently claimed that they had improved their subject knowledge and typically, 80% of participants report that they enjoyed the coursework. The results are remarkably consistent over three separate cohorts and the small improvement over time suggests appropriate developments have been made. We have not surveyed an equivalent research project using traditional reporting methods but speculate that these figures would represent a significant improvement.

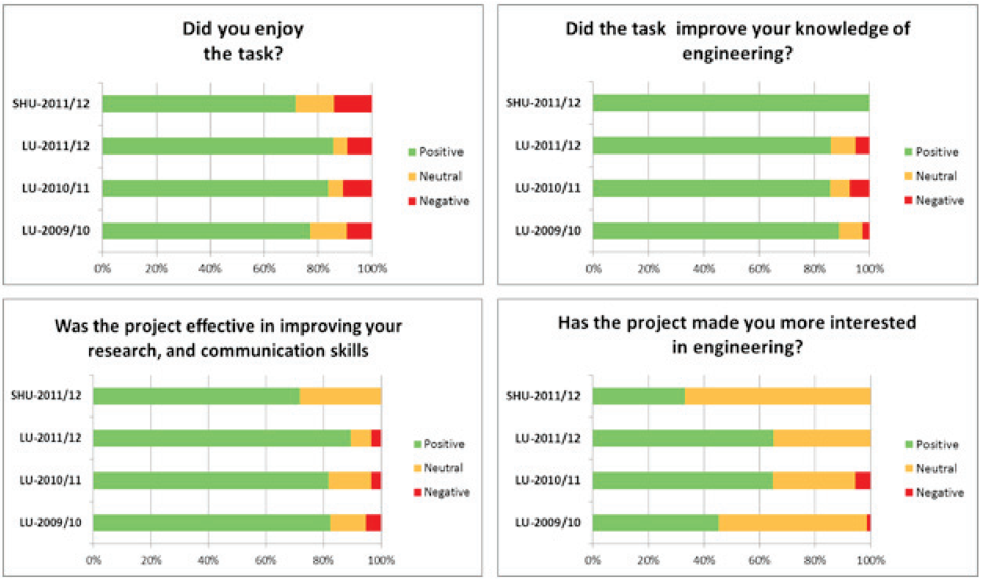

FIGURE 2. *Selected responses from the online questionnaire.*

The main identified outcomes from the combined feedback are:

- increased student motivation
- enhanced learning experience
- higher marks
- development potential for deeper learning of the subject
- development of learner autonomy
- enhanced team working and communication skills
- a source of evidence relating to skills for interviews
- learning resources for future cohorts to use
- opportunities for staff development - (CPD)

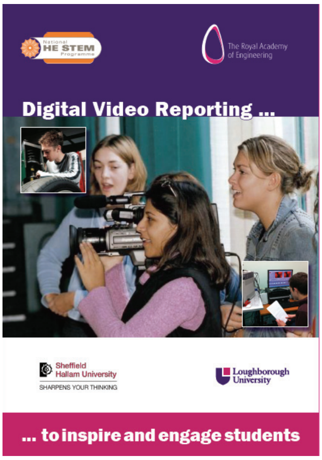

FIGURE 3. *Video toolkit folder.*

2.3 The 'toolkit' resource for lecturers.

A colourful loose-leaf resource pack (see figure 3) has been generated containing three distinct case studies and a fully referenced refereed paper describing the development of the idea and providing qualitative and quantitative evidence from the two universities of the potential benefits of the method. The pack also contains the comprehensive DVD, showing examples of student work, edited interviews with stakeholders from both institutions, video training resources for student self-teaching and printable advice sheets that can be adapted or incorporated into new projects. Most of the self-teach video production resources have been produced specifically for this project but there are also links to useful external websites.

The authors took account of feedback from earlier dissemination events [e.g.7]. when compiling the 'toolkit'. These events had clearly demonstrated there was a need to provide a resource for potential adopters and gave a useful guide to what was required and, therefore towards its eventual contents. The resource provides specific advice using a combination of printed words and short video clips on:

- Briefing students
- Recommended equipment
- Story-boarding
- Audio and video editing
- Good practice in camera use
- Assessment methods and criteria
- Copyright issues

3 TRIAL AND EVALUATION

An evaluation workshop was organised by the Engineering and Design Education Network (EDEN) took place at Loughborough with 25 attendees from the HE community. The concept was enthusiastically received and many suggestions were recorded, to improve the effectiveness of the resource and to finally define the mode of delivery. Participants were asked why they might or might not consider implementing video reporting into their teaching and what additional advice and resources they would need. After collecting feedback, examples of resource materials were demonstrated and a discussion ensued to establish the most appropriate formats. The following is a list of the issues raised by delegates:

Drivers

- To develop Teamwork skills.
- Promote engagement.
- Use of today's technologies.
- To save having to read 300 reports and listen to 50 presentations
- Use as teaching resource / promotional / research material
- Future use by staff and students (training, CV etc.)
- Incorporating new skills

Concerns

- Would not wish to use this for a high coursework contribution to a module
- Skill contribution of each member could be difficult to assess.
- Assessment criteria.
- Submission (how?)
- Time taken / duration / time allowed
- Focus on the content, not the media.
- Doubts on suitability for: mathematical & analytical subjects, part-time students, overseas students.

Required resources

- Understanding of editing technologies: Technical skills, facilities and equipment.
- How to brief students: Need for examples of student videos, copyright instruction, assessment acceptability and criteria.
- Evidence of achievement of learning objectives.
- Student advice and instruction.
- Equipment booking?
- Guidance on production.
- Recommended software.
- Disseminate actual student's sound bites (to inform other students).

There was much discussion, in particular, concerning appropriate assessment methods. Assessment of a large number of written team project reports is notoriously tiresome and was always hoped that the video method makes the task more rewarding for staff but, nevertheless, there appears to be an initial reluctance in some to accept the validity of video assessment. The authors believe that, while the notion is real, the problems are not and the workshop discussion served to reinforce this view.

In academia, we universally accept the validity of written reports and oral presentations. In everyday life, we are quite familiar with professional reviews and critiques of both documentary films and non-fictional books where critical judgements are made about their quality and content. The criteria for assessment are, therefore similar, if slightly modified to suit the medium.

The assessment and feedback task has been found, in reality, to be straightforward; two staff members watch each documentary at the same time and independently rate it against fixed criteria. Grades associated with the institutions' generic assessment descriptor policy using terms like 'outstanding, good and weak' were used to assign grades against each criteria. The grades are later computed to give an overall numeric score. Feedback is provided using the same table and the grades against each criterion serve to show the teams where they excelled and where they could improve. Assessing 24, 10-minute videos equated to one day's work for two people and, for once, it was quite enjoyable. At both institutions and in many others, live oral reports in groups are also part of the normal assessment process.

Post-workshop feedback included the following comments;

> *I learnt "a new idea to engage students" and "the ease of video making, lack of technical facilities required". I might "integrate video assessment into my module(s) next year"..... "try this approach".*

One delegate requested advance copies of the resources so that he could try out the ideas immediately.

Creativity

Enquiry Based Learning (EBL) is founded on sound pedagogic principles but the additional effect of introducing video-media to the project work is less well established. Nevertheless, there is no doubting that both institutions are left with a good feeling about this method and that the idea provokes much interest in the community. Of course, not all students are enthused, indeed, some are put off by the additional work involved, but the feedback data show that these are in the minority. Asked what was the best thing about the project, some typical year-1 comments were, "Getting to do something more creative as a group." and "The format of presenting our findings allowed us to be creative and imaginative." Perhaps we are sometimes guilty of failing to recognise the unexpressed creativity in engineering students that evidently can provide much needed motivation to learn.

4 CONCLUSIONS

There is a good feeling about this project; as though we had something right with the vast majority of students appearing 'on-side'. Furthermore the evidence from the online surveys and focus groups is encouraging. We speculate that few conventional coursework assignments would prompt a response from 8 in 10 students that they had enjoyed completing it and were consequently engaged in their studies. The quality of the work submitted has regularly exceeded expectations both in technical content and in the ingenuity and creativeness used in reporting it. The survey data also demonstrated considerable success in achieving the outcomes of improved knowledge and transferable skills; at least, this was the students' perception.

Modern Video equipment is relatively cheap and easy to use and 21st century learners appear to have little difficulty in adapting to it without extensive specialised instruction. There is no need to provide professional quality equipment here.

This adventure has proved interesting and instructive for both staff and students. The toolkit that has been constructed is the product of the combined experiences of a multidisciplinary team from two institutions, who have combined two separate approaches to develop, evaluate and disseminate good practice and provide a useful resource for others.

Further Development

There is an obvious potential to transfer or duplicate this training resource to the World Wide Web in order to extend its outreach. This however is beyond the scope of the present project. Any such extension should capture the wider experience that it promotes to further inform the method.

5 ACKNOWLEDGEMENTS

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141 INNOVATIONS IN THE CIVIL ENGINEERING CURRICULUM AT UNIVERSITY COLLEGE DUBLIN, IRELAND

Patrick J. Purcell[1]

1 School of Civil Structural and Environmental Engineering, University College Dublin (UCD), Ireland, PJ.Purcell@ucd.ie

ABSTRACT

The paper describes some examples of innovative developments in the 4-year undergraduate Civil Engineering curriculum at UCD. The developments described were undertaken to stimulate active learning and higher order thinking. The following examples of innovative teaching strategies will be described in the paper:

1. The introduction of a problem-based learning introductory session to the discipline of Civil Engineering for second level students.
2. The introduction of a 'Creativity in Design' module for first year engineering students.
3. The use of digital technology to create virtual laboratories can be used to supplement or even, in some instances, replace physical laboratories.
4. The incorporation of disasters and incidents into the curriculum enables students to appreciate the roles, responsibilities and work practices of engineers in a way that would not be possible in a conventional lecture room setting.
5. The use of peer-assisted mentoring, i.e. the use of students more advanced (e.g. post-graduate students) to mentor undergraduate students.

Keywords: Civil Engineering education, Student engagement, Innovative teaching.

1 INTRODUCTION

There have been numerous calls to broaden the education of engineers and thus prepare them to serve society with an awareness of and sensitivity to the cultural, political, economic and social dimensions of their work [1]. Jennings et al. [2] state that engineering students 'need to be aware of the importance of human as well as technical factors in the work they do, and the need to appreciate that communication skills and the ability to work with others are vital'. For example, Engineers Ireland requires that, in addition to the normal technical competence expected of a professional Engineer, graduates must be able to demonstrate:

- An understanding of the need for high ethical standards in the practice of engineering, including the responsibilities of the engineering profession towards people and the environment;
- The ability to work effectively as an individual, in teams and in multi-disciplinary settings together with the capacity to undertake lifelong learning;

- The ability to communicate effectively with the engineering community and with society at large [3].

The University College Dublin (UCD) Strategy for Education and Student Experience 2009 – 2013 Framework document states that 'the formation of creative and innovative graduates is our principal educational objective. Whether or not our graduates possess these attributes depends on the nature of he students attracted to the University, the learning environment created by the University and the success or otherwise of the students' engagement with the learning environment' [4]. This paper will describe how the Civil Engineering curriculum at UCD dovetails into the overall University educational objective of creating innovative and creative graduates. In particular, as illustrated in Figure 1, the paper will describe novel methods:

(i) of attracting second level students to civil engineering as a career;
(ii) engaging engineering students and making their educational experience more rewarding;
(iii) delivering elements of the programme in a more innovative manner.

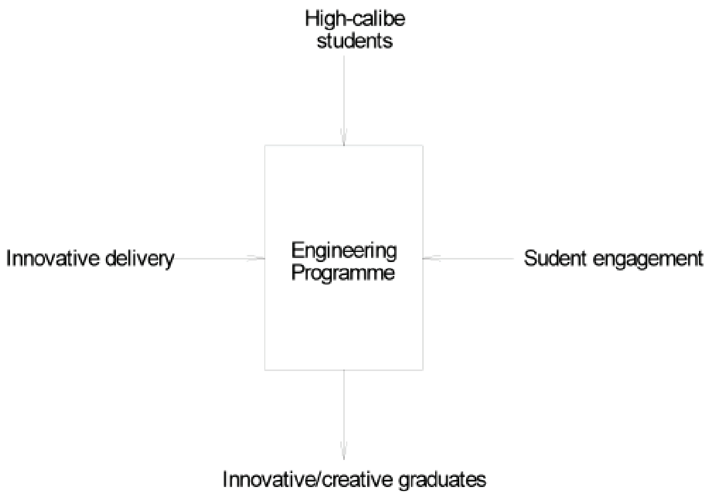

FIGURE 1. *Schematic of educational objectives at UCD Engineering.*

2 CIVIL ENGINEERING PROGRAMME AT UCD

The UCD Civil Engineering bachelor's degree has traditionally been a four-year 240-credit degree programme, although, in line with Engineers Ireland and the Bologna requirements, is moving gradually to a two-cycle five-year degree structure. Students must undertake core curriculum modules, and where applicable, can select option modules from a suite of specified modules. In addition, in the first three years, take two elective modules each year from any programme across the University. Table 1 summarises the number of core, option and elective modules that students of the current four-year Civil Engineering programme take in each Stage (Year) of their studies. In respect of the elective choice, students can choose either:

(a) two in-programme electives which enable students to deepen their engineering knowledge,
(b) two non-programme (general) electives which allow students to widen their knowledge in modules of general interest to the student or
(c) one in-programme elective combined with one general elective.

One of the key objectives of introducing general electives into the undergraduate engineering curriculum at UCD was to develop the non-technical attributes listed above in engineering students graduating from UCD.

TABLE 1. Number of modules per stage of the 4-year.

	Core	Option	Elective
Stage 1	10	0	2
Stage 2	10	0	2
Stage 3	10	0	2
Stage 4	8	4	0

3 STUDENT RECRUITMENT

A clear objective of any high-quality undergraduate engineering programme is the attraction of high-calibre students into the programme. Students generally enter the Civil Engineering programme at UCD via a national Central Applications Office and must primarily demonstrate high numerical ability. As part of an annual, one-week, UCD 'Experience Engineering' Programme for second-level students interested in pursuing Engineering as a career, a problem-based introductory session to the discipline of Civil Engineering for these students was developed, as described by Cosgrove et al. [5] . The purpose of this exercise, in which participating students undertake a Structural Engineering challenge, is to foster an interest amongst the participating students in Engineering as a career.

The objective of the Structural Engineering challenge is to design and construct an efficient truss structure, using limited material resources, to:

- to span a clear distance;
- to carry the maximum load at mid-span;
- to minimize mid-span deflection.

Students, as illustrated in Figure 2, are divided into groups of about 5-6 students per group. The exercise demonstrates the following attributes:

- Engagement by the students;
- Application of theory in context;
- Ingenuity by students;
- Competitiveness between groups;
- Teamwork building.

FIGURE 2. *Second-level students in Structural Engineering challenge.*

4 STUDENT ENGAGEMENT

Student engagement entails adopting pedagogical approaches that stimulate active learning and higher order thinking. There are tried-and-trusted techniques to keep students active-learners:

- Interactive lectures;
- Active learning;
- Peer-assisted mentoring.

Interactive lectures are lectures interspersed with brief in-class activities that require students to use information or concepts presented in the lecture. Students learn by doing, not by watching and listening. Felder [6] defines active learning as 'anything course-related that all students in a class-session are called upon to do other than watching, listening and taking notes'. One technique for promoting student engagement is the use of peer-assisted mentoring, i.e. the use of students more advanced (e.g. post-graduate students) to mentor undergraduate students. Peer-assisted mentoring should not be confused with 'normal' tutoring of undergraduates, in which the tutors are financially compensated. In peer-assisted learning, there is an educational gain for both the mentoring students and the mentees and all students are awarded credit for their respective roles in the educational arrangement.

An example of active-learning facilitated by peer-assisted mentoring in the School of Civil, Structural and Environmental Engineering at UCD is described below [7]. The first-year undergraduate module in question is 'Creativity in Design' (CVEN10040) and the postgraduate module is 'Innovation Leadership' (CVEN40390). The 'Creativity in Design' module provides an active-learning engineering experience through which students develop their observation skills, problem solving skills and lateral thinking and teamwork abilities. Undergraduate students work in small groups, facilitated by a post-graduate student, and suggest innovative solutions to real-world problems that are presented to them.

FIGURE 3. *UCD First Year Engineering module "Creativity in Design", Gibney, 2010* [7].

5 INNOVATIVE PROGRAMME CONTENT AND DELIVERY

5.1 Innovative content

The ASCE Technical Council on Forensic Engineering promotes the inclusion of failure-related case studies in professional engineering curricula [8]. Incorporating these studies enables students to gain knowledge of the roles, responsibilities, priorities and work practices of engineers in a way that would not be possible through lectures.

As part of the Stage 4 Civil Engineering Design module at UCD, students undertake weekly case studies on Structural, Environmental and Geotechnical Engineering. As part of the Environmental Engineering component of the module, the author introduced environmental failure/incident case studies. Students work in groups of about five students per group. Each group examines a particular incident/disaster, for example: contamination of drinking water supplies, pipeline failures, pollution from wastewater discharges etc.

One of the difficulties relating to any group-based exercises is the issue of individual student assessment. To overcome these difficulties, each student must make an individual presentation and written report on their individual theme and contribution to the group project. The themes which the students must examine include: technical, legal, response, safety, policy, responsibilities, communication, lessons.

5.2 Innovative delivery

The use of computer-based technology can be particularly useful in enhancing engagement, in delivering more effective assessment and in providing timely feedback. 'Virtual' laboratories can be used to supplement or even, in some instances, replace physical laboratories. The rationale for introducing virtual laboratories at UCD School of Civil Structural and Environmental Engineering is that, in a time of diminishing resources, virtual laboratories can go some way to bridging the gap between demand and capacity to deliver laboratory-based practicals.

Within the Highway Materials component of the Civil Engineering Design modules, Stage 4 Civil Engineering students have traditionally undertaken laboratory demonstrations in small groups. To improve the student experience, a video library of on-site activity and laboratory testing methods has been developed, facilitating students in appreciating and understanding the practical elements of their programme, as illustrated in Fig.4. Future development of this innovative method of delivery would be to link virtual laboratories with on-line MCQ assessment, as illustrated below:

- How do students view virtual laboratories?
  - Upload onto Virtual Learning Environment;
  - Description of experiment;
  - View Video;
- Student assessment?
  - Assessment linked to learning;
  - Multiple Choice Questions on video clip;
  - Progression from one experiment to another.

FIGURE 4. *Developing virtual laboratories, Gibney, 2010 [9].*

6 CONCLUSIONS

Some examples of innovative developments in the undergraduate Civil Engineering curriculum at UCD have been described. These initiatives range from measures to attract secondary school students into the profession, to stimulating undergraduate student engagement through the use of novel content and delivery methods. Anecdotal evidence and quantitative student feedback suggests that the foregoing initiatives have enhanced the student experience.

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142 PARZIVAL MEETS MODERN ARCHITECTURE

Tamás Molnár[1]

1 University of Pécs Pollack Mihály, Faculty of Engineering and Information Technology, tmolnar@pmmik.pte.hu

ABSTRACT

Parzival meets modern architecture is the title of an Erasmus Intensive Program. Five universities are cooperating in this international student program. Coordinator of the program is the Fachhochschule Joanneum University of Applied Sciences from Graz, Austria. Project partners are the Dresden University of Applied Sciences, the Chalmers University of Technology from Goteborg, the Liverpool John Moores University and the University of Pécs. Altogether 56 students from five countries are trying to find a solution for the revitalisation of the Castle of Borl in Slovenia. The Castle of Borl was originally built in the 11-12th century. Its other name is the Castle of Ankenstein. It is located on a cliff over the river Drava. The history of the castle is somehow related to the legend of Parzival. As the building is situated in a beautiful landscape it is really important for the Slovenian government to find a solution for the function and for the future of Borl. The international cooperation of the above mentioned five universities can help local and national authorities to decide how the Castle of Borl should be developed.

Keywords: Borl, Castle, workshop, Erasmus

1 INTRODUCTION

Borl Castle stands on a steep rocky ledge above an ancient pass over the River Drava. It was first mentioned in 1199. Myths even connect it with the search of the Holy Grail and Parzival. Wolfram von Eschenbach wrote a romance about the story of Parzival. The area of Hajdina and Ptuj belonged to the kingdom of Gandin, the grandfather of Parzifal. Gahmuret, Parzifal's father was the builder of the ancient tower in the middle of Castle Borl. Among the numerous owners of the castle were the Ptuj feudal lords, and after them the Herbersteins, Turns, Sauers and others. During World War II the castle was an internment camp, and after the war it was converted into a hotel. In 1981 the hotel was closed and later the building was emptied and abandoned. Recently the state has taken over the care of it and has restored it architecturally (see Figure 1).

Borl has a multilayer building design with distinguishable continuing development. The castle complex consists of a core from the 13th century with an early Gothic defence tower and a residential tract. The outer walls are extremely thick. The first inner courtyard, peripheral fortification architecture, residential tracts and arcade halls have been rebuilt several times. They were thoroughly redone in the first half of the 17th century. Around 1674 (redone after a fire in 1706) the tract by the outer courtyard was rebuilt, where the Baroque Chapel of the Holy Trinity was set up. They added a small clock tower as decoration. The portal of the central tract is great quality work by a stonemason. At the courtyard there is a cistern of extraordinary dimensions, and there is another one at the edge of a smaller yard. The decoration and furnishings of the inner areas have been partly preserved. One of the representative areas in the castle is the Knights' Hall. The room next to it has a painted ceiling. The Baroque sculptures of Hercules and Florian have been moved to the hall. Paintings from the chapel were stolen in 1993.

FIGURE 1. *Castle of Borl from the clock tower.*

Below the castle there are only the remains of the former garden. Due to the lack of space the garden at the foot of the hill has been more ambitiously designed. By the centrally located pavilion, the square sections were arranged geometrically. The inner ones were ornamented and the outer were probably designed for growing vegetables and herbs. The garden was surrounded by a wall and four ornamented portals opened onto it. An avenue planted with trees on both sides connected the castle with the garden. Only individual trees have been preserved and the Baroque composition has disappeared. Reconstruction is possible in the empty area on the basis of the preserved graphic scheme and analogies. [1]

2 WORKSHOP

The Fachhochschule Joanneum University of Applied Sciences Graz applied for an Erasmus Intensive Project with the title Parzifal meets modern architecture. During the 12 days' workshop 56 students from five countries tried to find a solution for the reconstruction, reuse of Castle Borl. Students of architecture from the following universities were participating:

a) Fachhochschule Joanneum University of Applied Sciences, Graz, Austria
b) Chalmers Technical University, Goteborg, Sweden
c) HTW University of Applied Sciences, Dresden, Germany

d) University of Pécs, Pollack Mihály Faculty of Engineering and Information Technology, Pécs, Hungary
e) John Moores University, Liverpool, United Kingdom

The main questions of the workshop were the appropriate function for the castle and the type of reconstruction that can bring life among the old walls again. At the beginning on behalf of the FH Joanneum Mr Wolfgang Schmied the Head of Architecture Studies welcomed the participants. Just afterwards Mr Miha Pogačnik, the Cultural Ambassador of Slovenia emphasized the uniqueness of Castle Borl and presented the connection points to the story of Parzival with a violin performance. During the first two days of the workshop students visited the castle and its surroundings (see Figure 2).

FIGURE 2. *The group of students together with the lecturers in the castle.*

The participants made an excursion to Graz to see a series of executed projects with a connection between old and new. As the starting out of the technical program a symposium took place where the lecturers of the participating universities and some local architects presented different projects of listed buildings. Students worked in international groups so they had the possibility to see different working methods (see Figure 3). Lecturers were actually the tutors of the groups and they helped the students to find a concept for the castle.

FIGURE 3. *Students working on the projects.*

On the last day the 14 student groups presented their first ideas about the building. 1-3 prizes were awarded to the groups and three honourable mentions were also given to the students. [2]

3 CONCEPT

At the result of the workshop the relationship to the existing castle building was really interesting. Some of the groups tried to leave it there as it is and planned only the minimally needed renovation for the old part. These groups usually designed a new building or a new wing somewhere around the castle. Other groups tried to turn the castle into something new by reconstructing the main parts, demolishing some parts of the existing structure. The main problem was the function. The question was how to emphasize a building like the Castle of Borl in the middle of nowhere, in a region where a lot of larger castles can be found.

1st prize was awarded to the group Feeling and Heeling in Castle Borl (Sara Bärling – Chalmers University, Bradley Burrow – John Moores University, Marcel Timmroth – HTW Dresden and Daniel Wundersamer – FH Joanneum). They planned a unique recreation centre into the castle. 2nd prize was awarded to the group Musical epic to future visions (Anne Klepal – Chalmers University, Bernadett Tóth – University of Pécs, Antony O'Meara – John Moores University and Petra Kogler – FH Joanneum). The idea of this group was to plan a new way full with different information stops and experience points from Ptuj to the castle and to establish a Cultural Center for Musical Exchange in the Castle of Borl. 3rd prize was awarded to the Renovation Project (Anett Mizsei – University of Pécs, Kimberly Mountford – John Moores University, Thomas Steinwidder – FH Joanneum and Daniel Kotrasch – FH Joanneum). These groups tried to plan a solution where volunteers will be taught to different skills by local craftsmen and they will restore the castle during their studies. [2]

The groups that received honourable mentions found three different solutions. First was a special winery as the Castle of Borl is located in the famous wine region of Slovenia, namely

Haloze (see Figure 4). Second was a dancing school where people have the possibility to explore the building through their bodies. Third idea was to establish the place of opportunities where students can apply for different scholarships to study something that belongs to art, music or theatre in the castle.

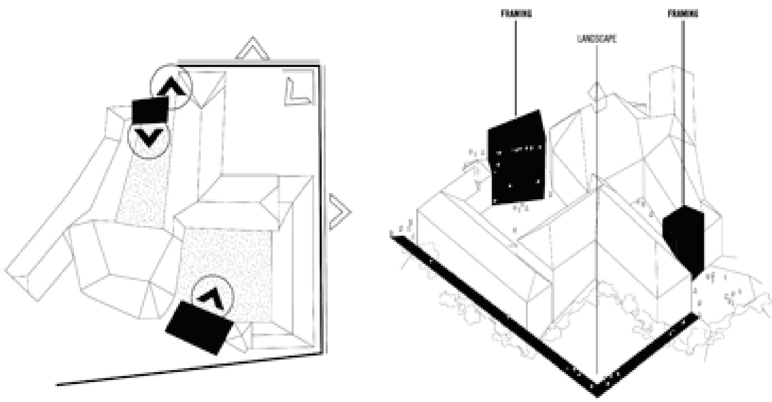

FIGURE 4. *One of the concepts (Authors: Yan Roche, Blanka Somi, Liam Sidwell, Mario Pürstl).*

4 CONCLUSION

The Author is of the opinion that workshops are important educational methods. Student can really feel the touch of real life as they have to work on something that possibly will be built or used later by investors, by city councils or even by governments. In the workshop series of Temporary City [3], where the author participated some years ago, the winner project was even constructed [4] [5]. This can be also very important for a student to plan something that will be realised. It is also good for students of architecture to work in groups. By a workshop they can study how to work as a member of a team. As the groups are international, participants can see different point of views. Of course it is also very important that students form connections with each other. These new friendships can be useful for them later in their lives.

Students will work out their own projects more in detail at home and their work will be exhibited in Maribor that is the European Capital of Culture in 2012. As a result hopefully the Slovenian government will have good ideas to know what to do with the castle or to find investors for the Castle of Borl.

5 ACKNOWLEDGEMENTS

The Erasmus Intensive Program with the title Parzival meets modern architecture is financed by the Erasmus Education and Culture Program (see Figure 5). The Author would like to thanks for the works of the organizers from the Fachhochschule Joanneum University of Applied Sciences Graz.

FIGURE 5. *Logo of Erasmus Education and Culture Program.*

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144 DOUBLE MASTER DEGREE PROGRAMME: ENHANCING MULTICULTURAL ENGINEERING AND MOBILITY BETWEEN FRANCE AND FINLAND

Sébastien Lafond[1] & Cecilia Brunel[2]

1 Åbo Akademi University, Sebastien.Lafond@abo.fi
2 ESIGELEC Rouen, School of Engineering, Cecilia.Brunel@esigelec.fr

ABSTRACT

Mobility and multiculturalism among engineering students in Europe are mainly accomplished through the ERASMUS student mobility programme. This programme contributes to the development of an integrated European labour market and increases the chance for participating students to work abroad later on [1]. However through the ERASMUS programme the length of the study period abroad cannot be more than twelve months and students only "collect" credits in the host institution to be recognized and transferred in their home institution.

The European labour market is driven by a knowledge-based economy and motivated students seeking to increase their assets on such labour market aspire for more than exchange periods abroad. Setting up double master degree programme between trusted institutions is the foremost move institutions can have towards these students. A double Master Degree Programme is a framework promoting multiculturalism where students get the opportunity to gain additional skills and competencies.

This paper presents a double master degree programme in Embedded Systems between a Finnish university and a French school of engineering. It shows how the Finnish three plus two years education system can be coupled to the French engineering system of two plus three years of studies.

Keywords: Double Master Degree, Engineering, Finland, France

1 INTRODUCTION

When looking at the mobility and multiculturalism opportunities among engineering students in Europe, the development of the ERASMUS student mobility programme is definitely a success story. The programme increases the chance for participating students to work abroad later on and contributes to the development of an integrated European labour market and an advanced knowledge-based society [1]. However, some motivated students seeking to increase their assets on the labour market aspired for more than exchange periods abroad.

Establishing double master degree programme between trusted institutions is the foremost move institutions can have towards these students. From the institutions point of view a double master degree programme facilitates the recruitment of foreign students. At the same time such programme can help them to stand out from the crowd and to better position them in the international labour market.

Indeed, with the current globalisation trend companies become closer to each other, and within companies the geographical distances and national borders are losing their meaning [2]. Moreover differences in the local culture of the employees can be problematic when the companies, partners and clients are spread all over the world [3] [4]. Very often trust as well as communication problems are linked to multicultural issues [5] [6]. A double master degree programme is also an attempt to train students in a multicultural environment such that they could easily cope with cross-cultural issues.

This paper presents a newly established double degree programme between a Finnish university, Åbo Akademi University, and a French school of engineering, l'École supérieure d'ingénieurs en génie électrique (ESIGELEC). It describes the structure of the programme and demonstrates the feasibility of such programme despite the substantial differences between the Finnish and French education systems.

ESIGELEC is a school of engineering created in 1901, i.e. a higher education institution offering long technical studies. It is recognised by the French government and supported by the Chamber of Commerce and Industry of Rouen in Normandy. The school is accredited by the "Commission des Titres d'Ingénieur" to award the ESIGELEC Diplôme d'ingénieur or Master's Degree in engineering, signed by the Ministry of National Education in the following fields: telecommunications, electronics, embedded systems, information technologies, networks, automation & robotics, electrical engineering, mechatronics, energy and sustainable development, biomedical engineering, business engineering, finance engineering. ESIGELEC also offers doctoral studies. Its research institute in Electronic Embedded Systems is nationally and internationally recognised in the automotive, aeronautics, electronics and telecommunications areas.

Åbo Akademi University is a medium-size, public, multidisciplinary and Swedish-language university, celebrating its establishment in 1918. Åbo Akademi University offers both undergraduate and graduate studies and extensive research opportunities to some 7000 students on three campuses. It has an acknowledged position at the forefront of research in such areas as biosciences, computer science, democracy, human rights, material sciences, process chemistry and psychology.

1.1 Different Engineering Education Systems

The Finnish engineering education system is based on the framework adopted in the Bologna Process defining three cycles of higher education qualification. Students in Finland are awarded in the first cycle a Bachelor's degree in Engineering (180 ECTS) after three years of full time studies and a Master's degree in Engineering (120 ECTS) in the second cycle after two years of full time studies in a Finnish university like Åbo Akademi University.

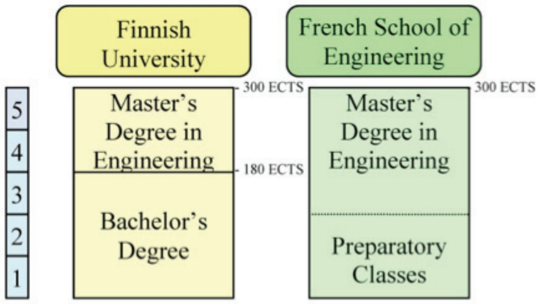

FIGURE 1. *Overview of the French and Finnish Engineering Education System.*

On the other side, higher engineering education in France is essentially provided by non-university institutions dedicated to specific subjects. The Master's degree in Engineering is awarded to students by state-recognized schools of engineering (Ecoles d'ingénieurs) after five years of study. Master's degrees from these schools of engineering are often favoured over university degrees because of their selective admissions procedures based on competitive written and oral exams. Students in France are admitted in a school of engineering after two year of full time studies and are awarded a Master's degree in Engineering (300 ECTS) after three years of full time studies in a school of engineering.

Figure 1 illustrates the difference between the three plus two years scheme of the Finnish engineering education systems (three years of bachelor followed by two years of master studies) and the two plus three years scheme of the French engineering education systems (two years of preparation followed by three years of engineering studies).

2 DESCRIPTION OF THE DOUBLE DEGREE PROGRAMME

Through this 6 semesters programme, including two mandatory placements, students will be able to gain two Master level degrees: the Diplôme d'ingénieur from the French school of engineering and the Diplomingenjör from the Finnish university. Participating students are pre-selected by their home institution before being accepted by the host institution on the basis of their applications and study merits. The programme languages of instruction are English, French and Swedish.

This programme was established in the end of 2011 and the first enrolled students are expected to start in August 2012. The maximum number of accepted students from each institute is five.

Through this double degree agreement, Åbo Akademi University offers students from ESIGELEC the opportunity to participate into the programme in order to graduate with the degree of Master of Science in Technology (120 ECTS) awarded by Åbo Akademi University. Reciprocally, ESIGELEC offers students from Åbo Akademi University the opportunity to participate into the engineering cycle leading to the Diplôme d'ingénieur (300 ECTS) awarded by ESIGELEC. Figure 2 illustrates the timeline of the double degree programme compared to the French and Finnish standard programmes.

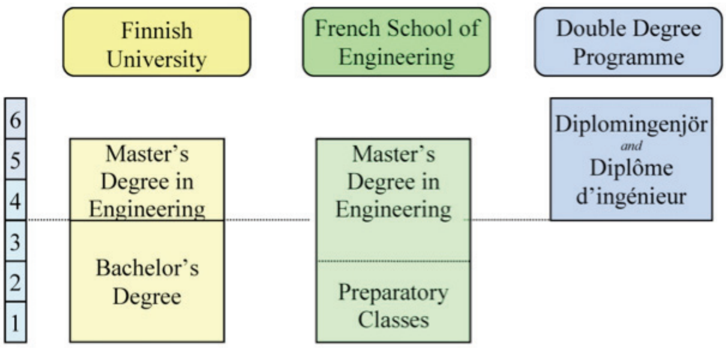

FIGURE 2. *Timeline of the Double Degree Programme Compared to the Standard Programmes.*

2.2 ESIGELEC Students going to Åbo Akademi University

Students from ESIGELEC participating in this programme are selected by ESIGELEC after having completed 4 years of study in higher education. In order to graduate with the Master of Science in Technology, ESIGELEC students must stay under the academic control of Åbo Akademi University during four academic periods and one internship which has to be approved by both Åbo Akademi University and ESIGELEC. Figure 3 illustrates the academic calendar students need to follow in order to graduate from both institutes.

After completing 4 academic periods at Åbo Akademi University, students from ESIGELEC must carry out an internship in a company, research centre or university, in France or in Finland or in any other country of their choice. The internship is under the academic responsibility of ESIGELEC and Åbo Akademi University. The internship is to be assessed by Åbo Akademi University in relation with the host company, research centre or university, and with ESIGELEC.

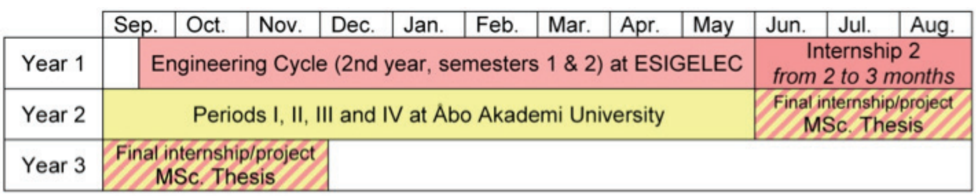

FIGURE 3. *Academic Calendar for ESIGELEC Students going to Åbo Akademi University.*

The structure of the programme and the required ECTS for ESIGELEC students going to Åbo Akademi University is illustrated in table 1. Students will need to gain ECTS credits from 6 course modules and write one master thesis which is going to be approved by both institutes. Credits gained at Åbo Akademi University are transferred to ESIGELEC in order for the students to be awarded the Diplôme d'ingénieur from ESIGELEC. In the same way credits gained at ESIGELEC are transferred to Åbo Akademi University in order to be awarded the Diplomingenjör from Åbo Akademi University. Two compulsory foreign languages, English and Swedish, are required in the compulsory language courses module.

TABLE 1. Structure of the modules for ESIGELEC Students.

Module	Required ECTS		Total
	From ÅA	From Esigelec	
1. Advanced module	15	5	20
2. Compulsory advanced module	-	20	20
3. Project course	10	-	10
4. Compulsory intermediate studies	5	15	20
5. Compulsory language courses	8	-	8
6. Free optional courses	6	6	12
7. Master's thesis	30		
TOTAL	120		

2.3 Åbo Akademi University Students going to ESIGELEC

Students from Åbo Akademi University participating in this programme are selected by Åbo Akademi University after having completed 4 academic periods in the Master of Science in Technology of Åbo Akademi University. In order to graduate with the French "Diplôme d'ingénieur", students from Åbo Akademi University must stay under the academic control of ESIGELEC during 4 semesters: three academic semesters and one internship semester which has to be approved by both Åbo Akademi University and ESIGELEC. Figure 4 illustrates the academic calendar students need to follow in order to graduate from both institutes.

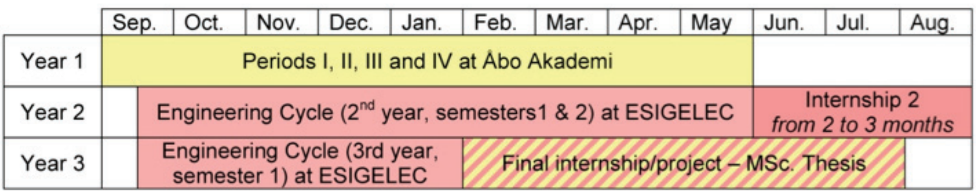

FIGURE 4. *Academic Calendar for Åbo Akademi University Students going to ESIGELEC.*

After completing a minimum of 3 academic semesters at ESIGELEC, students from Åbo Akademi University must carry out an internship in a company, research centre or university, in France or in Finland or in any other country of their choice. The internship is under the academic responsibility of ESIGELEC and Åbo Akademi University. The internship is to be assessed by ESIGELEC in relation with the host company, research centre or university, and with Åbo Akademi University.

In order to graduate from ESIGELEC students from Åbo Akademi University must follow the same curriculum as regular ESIGELEC students from the second and third year of the engineering cycle. In addition students will have two compulsory foreign languages: English and French as foreign language. The ESIGELEC curriculum for the second and third year of the engineering cycle is illustrated in Figure 5.

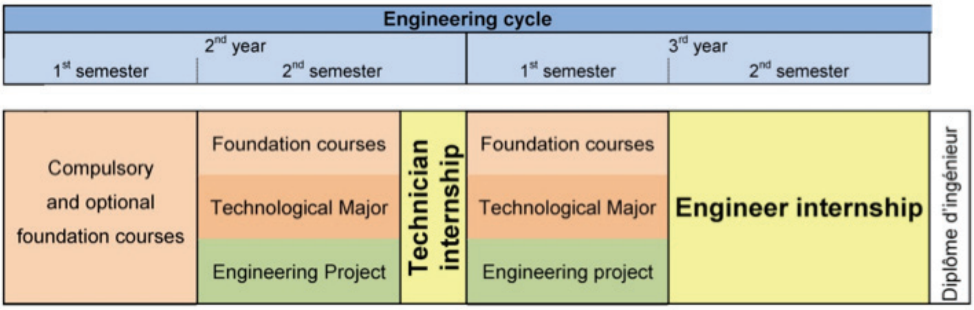

FIGURE 5. *Second and third year of the engineering cycle at ESIGELEC.*

In order to graduate from Åbo Akademi University the students will have to follow the structure of modules illustrated in Table 2. Students will need to gain ECTS credits from 6 course modules (the same as in Table 1) and write one master thesis which is going to be approved by both institutes. Credits gained at ESIGELEC are transferred to Åbo Akademi University in order to be awarded the Diplomingenjör from Åbo Akademi University. In the same way, credits gained at Åbo Akademi University are transferred to ESIGELEC in order for the students to be awarded the Diplôme d'ingénieur from ESIGELEC.

TABLE 2. Structure of the modules for Åbo Akademi University Students.

Module	Required ECTS		Total
	From ÅA	From Esigelec	
1. Advanced module	8	12	20
2. Compulsory advanced module	15	5	20
3. Project course	10	-	10
4. Compulsory intermediate studies	5	15	20
5. Compulsory language courses	-	8	8
6. Free optional courses	6	6	12
7. Master's thesis	30		
TOTAL	120		

2.4 Programme coordination

ESIGELEC and Åbo Akademi University have an overall coordinator for the programme in each institution. The coordinator will serve as the contact person on campus, being responsible for promoting the programme, informing students and giving appropriate advice, for arrangements associated with visits, ensuring that necessary approvals are in place and the general welfare of the students.

Figure 6 illustrates the application procedure. The home institution will be responsible for screening and selecting students, subject to acceptance by the host institution. Students apply to the host institution via a simplified procedure which consists in sending an application file to the host institution coordinator of the programme. After a possible interview, the host institution grants admission to the double degree programme on the basis of the application and study merits of the selected student from the home institution.

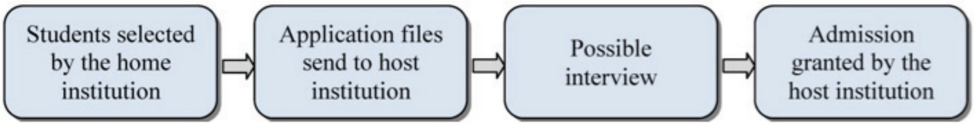

FIGURE 6. *The Application Procedure.*

3 CONCLUSION

This paper introduced a double master degree programme in Embedded Systems between a Finnish university and a French school of engineering. It shows through a concrete example how the Finnish three plus two years education system (three years of bachelor followed by two years of master studies) can be coupled to the French engineering system of two plus three years of studies (two years of preparation followed by three years of engineering studies).

For the participating institutions the programme facilitates the recruitment of foreign students. For the students this framework promotes multiculturalism and gives the opportunity to gain additional skills and competencies. Such programme can help them to acquire cultural awareness and therefore better position them in the international labour market.

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145 ENHANCING ENGINEERING EDUCATION AND UNIVERSITY-INDUSTRY COLLABORATION BY SIMULATION TOOLS

Teijo Lahtinen[1], Arttu Salmela[2] & Henri Koukka[3]

1 Lahti University of Applied Sciences, Lahti, Finland, teijo.lahtinen@lamk.fi
2 Raute Corporation, Lahti, Finland, arttu.salmela@raute.com
3 Lahti University of Applied Sciences, Lahti, Finland, henri.koukka@lamk.fi

ABSTRACT

Lahti University of Applied Sciences (LUAS) and Raute Corporation carried out a simulation project with local companies during 2010-2011. The main objectives of the project were to disseminate the state-of-the-art technology in simulation between the companies and LUAS and to find means to accelerate hands-on activities and active learning in engineering education. This paper is based on the main results of that project. The paper presents practical examples how simulation tools can be utilized in engineering education and university-industry collaboration. The paper also includes a description of the Raute Corporation Case: how Raute Corporation utilizes simulation in different phases of a product cycle, from product development to after sales.

Keywords: Simulation, University-Industry Collaboration, Engineering Education

1 INTRODUCTION

As pointed out by R. Shannon “Simulation is art and science”, simulation is defined as the process where systems in the real world are designed in a virtual manner. These models which are representatives of real world cases are used as a tool for testing and evaluating the behavior of different kinds of systems. On a larger scale simulation can be anything from simple role play to a highly impressive graphical representation of the virtual world. Between these two borders fall lots of different categories of simulation [1].

There are endless possibilities to utilize simulation tools in order to enhance engineering education and university-industry collaboration. The spectrum varies from the simulation of a single electric circuit to the intelligent simulation models of production lines and machines in industry. With the simulation tools, practical hands-on learning activities can be carried out and accelerated in a cost effective and safe manner. In industrial enterprises the “bottlenecks” of the production systems can be detected and commissioning processes speeded up.

In engineering education the basic 3D models can be converted into “intelligent” simulation models by modern simulation tools. For example PLC (Programmable Logic Controller) programming exercises can be carried out by using simulation models instead of real machines. The same idea can be applied to almost every study course. Practical learning becomes more controllable (larger groups), more effective (less dead time), more economic and safer.

Customer driven manufacturing in industry requires shorter delivery times and a more efficient commissioning process. The planning, manufacturing and commissioning processes can be rationalized by the simulation tools. Raute Corporation is one of the leading pioneers to make the most of the benefits of simulation tools in Finland. By utilization of simulation in planning, manufacturing and commissioning processes the enterprises can improve their material and energy efficiency as well as sales and logistics services. Companies can get a significant cutting edge compared to their competitors [2] [3].

2 EXAMPLES OF SIMULATION CASES CARRIED OUT IN LUAS

There is a large variety of simulation software tools available in different applications, both open source (robot simulator tool USARSim) and commercial ones (ABB Robot Studio) [4] [5]. In Table 1, you will find the main simulation tools for applications used in LUAS.

Multisim is the schematic capture and simulation application of National Instruments Circuit Design Suite, a suite of EDA (Electronics Design Automation) tools that assists you in carrying out the major steps in the circuit design flow. Multisim is designed for schematic entry, simulation, and feeding to downstage steps, such as PCB layout [6].

TABLE 1. Simulation Tools Used in LUAS.

	Simulation Tool	Applications
	MultiSim (National Instruments)	DC and AC Circuits, DC and AC Motor Controllers, Computer Electronics
	PowerSim	Mathematics (Dynamic Simulations)
	MatLabSimulink	Control Engineering etc.
	Festo FluidSim	Pneumatics, Hydraulics
	Siemens STEP7 PLC Sim	PCL Programming and Testing
	LUSAS (FEA Limited)	Strength of Materials
	3D Create (Visual Components)	Production Lines and Machines, PLC Programming and Testing
	ABB Robot Studio	Robot Cell Planning and Programming
	AVD Manager and Emulator (AVD = Android Virtual Device)	Android smart phone and tablet software development and application testing
	Windows Phone Emulator	Windows Phone software development and application testing
	QT Simulator	QT mobile software development and application testing (Win CE+mobile, Embedded Linux, Symbian, Maemo)
	AVR Studio (built in simulator)	Atmel AVR microcontroller software development

Multisim is used on basic and advanced courses of Electrical Engineering and Electronics to simulate for example basic DC and AC Circuits and DC (DC Chopper) and AC Motor Controllers (Frequency Converter). Through dynamic simulations in mathematics the students can deepen their understanding of differential equations. In control engineering courses MatLab Simulink is used to simulate for example PID-controllers. Festo FluidSim is a main tool for Pneumatics and Hydraulics. Siemens STEP7 PLC Sim works as a virtual test bed in PLC (Programmable Logic Controller) programming and testing. The strength and behavior of mechanical structures under different loads can be investigated with LUSAS software. LUSAS analyzes the structures with Finite Element Method (FEM). In telecommunications mobile phone and microcontroller simulators and emulators are used.

ABB Robot Studio is a simulation tool for ABB Industrial Robots. You can create system layouts of robot cells, model mechanisms (grippers for example) and run basic PLC Simulations [5]. With 3D Create software basic 3D-models can be converted into "intelligent" simulation models: you can create intelligent 3D-models which simulate real machines and production lines. These models can be connected to the PLC programming tools (Siemens STEP7 and Beckhoff TwinCat) online.

3 ANIMATION AND SIMULATION DRIVEN COLLABORATION PROJECTS AS PART OF MEDIA TECHNOLOGY STUDIES

The Degree Programme of Media Technology at Lahti University of Applied Sciences has a long history of university-industry collaboration, especially in the field of simulation and animation. Many industrial companies have found animation and simulation useful ways to design, test, train and market their products. This is the place where media technology can significantly help local companies and meet their needs. That is the main reason for the high volume of projects carried out in collaboration with local industrial companies. More than 50 projects have taken place over the last 8 years.

The purpose of collaboration and partnership with companies is to bring real world cases to students. The curriculum of the Degree Programme of Media Technology is based on the idea of learning through projects. The curriculum consists of modules which cover a vast variety of technical topics. Every year these learned topics are tested in real world projects. These projects can combine together programming, web technologies, multimedia, video, 3D modeling, 3D animation and simulation. This is a place where project management skills and capability to learn fast are important.

Multimedia-based teaching has proved a successful and inspiring method in education [7] [8]. The same trend has been seen in the latest collaboration projects. No matter if a multimedia product is commercial material or something which is planned to be used for training; companies usually want more than a simple animation. Combining 3D modeled and animated content in a multimedia framework has been a popular solution. In the most cases this framework mean user interface made by Adobe Flash. This technique expands the user's control over the animation. Without this all the user can do is to play, stop and rewind the animation. With a sophisticated user interface customers can get extra value from the animation. This value can be achieved for example with extra textual information that can be called out if the user wants to know more than what the animation itself shows.

3.1 Project example of Degree Programme of Media Technology

Usually projects start with a contact of a customer. After problem definition the faculty staff forms a project group consisting of 3-4 students. The group, faculty staff and the customer will meet in a kick-off meeting. After the meeting the project group will divide the project to reasonable pieces and try to get the most efficient combination of skills and knowledge to solve each problem. In normal cases three main types of skills are needed: 3D modeling/animation, visual design and interface design/programming.

Animation case: Recycling stainless steel

A local company, StalaTech, needed a new way to convince their customers about the outstanding properties of stainless steel. StalaTech is sells stainless steel for the car industry, especially for the bus building industry. The main theme for marketing was sustainable values such as recycling and good corrosion resistance. At first glance the case was not very impressive and forming a group was quite difficult. For students the idea to make a 3D animation about recycling stainless steel did not appear very attractive.

The first meeting changed the feelings completely. The customer was very keen to have fresh and innovative ideas and gave free hands to carry out even a little bit wildish ideas. The animation was planned to be published at the stand of StalaTech at a bus industry exhibition in Belgium. That gave an idea of a loop able animation where a bus will be wrecked and recycled. With a loop there is no need to start the animation after every showing and it can run continuously on a screen.

The project got a tight schedule and the project group had to plan their roles very carefully. 3D modeling, texturing and lighting were the most time consuming parts of the work. Every member of the group did their own part of the animation and these parts were tested together regularly. From the very beginning it was clear that final rendering of the animation would be the bottleneck in the project. Therefore the group got exclusive rights for the use of render farm of faculty. Rendering still caused anyway problems and the resolution of the animation had to be lower than first planned. With lower resolution the animation finished just at the deadline.

4 CASE: SCOPE OF SIMULATION IN RAUTE

Raute Corporation is a technology company serving the wood products industry. Its most important customers are the plywood and LVL industries. Raute's customers are companies operating in the wood products industry manufacturing veneer, plywood and LVL (Laminated Veneer Lumber). Raute's technology offering covers machinery and equipment for the customer's entire production process. Raute had long term collaboration with Lahti University of Applied Sciences in the fields of wood processing, automation and simulation.

Raute began using Visual Components' 3D simulation products in 2006. Since then simulation has established itself as a valuable tool in Raute's business operations. There are three main areas for the utilization of simulation, which are:

- R&D and product development
- Sales and marketing
- Simulation services

This case study describes how the same simulation model can be used for many purposes through the product life cycle. Utilization of simulation starts early in the product development process and continues until the product support on the customer's site. Participants in the upstream process can deliver their outputs as inputs for the downstream process in the form of a simulation model. The simulation model is an effective tool for sharing the information from one organizational resource to another. Models that were originally developed to support product development are easily modified to support other operations, such as sales and marketing and simulation services.

4.1 R&D and product development

Product development is an iterative process which starts from the target specification that is based on customer needs. Design ideas are developed and then evaluated until the concept meets target specifications and requirements. Simulation models are used for virtual testing and visualization of ideas.

Simulation models enable rapid iteration loops and fast feedback. Models are easy and quick to update compared to heavy CAD systems. Several ideas can be created and tested during a single engineering workshop meeting. Both visual and functional aspects can be taken into account. In the concept development phase participants usually work in cross-functional teams where all participants have their own expertise. Visualization helps understanding and communication of complex systems and all participants can bring their ideas up.

The first models are simple 3D models that help visualization of dimensions and the layout of the equipment. Then the functionality of the mechanics is added. Finally sensors, signals and actuator parameters are included and tested. When the concept is proved to be feasible, simulation can be utilized by connecting the device into a larger system or manufacturing layout. Interaction between the new product and existing system can be studied. Possible problems and collisions are discovered at an early stage, which improves design quality.

Project designers can get their input as an operating simulation model. That speeds up the start of the design assignment. Automation engineers can use the model for understanding the line operation. They can decide where to install sensors. Critical PLC codes can be tested in a simulation model for speeding up production ramp up. Screenshots of 3D simulation models are often used in user interfaces of automated production lines.

4.2 Sales and marketing

People involved on sales and marketing are heavy users of simulation models. Plenty of products across all Raute's product platforms are modelled and included in the component library. Library components can be used such as they are or easily tailored to a specific customer need.

Simulation models are used as support material in presentations and discussions with a customer. A sales person can show production line configuration options, performance checks and clearly communicate ideas and recommendations.

The sales models are typically parametric, so that line dimensions can be modified instantly. Geometry of the simulation model can also be added to the customer's mill layout and models can be delivered to customer as 3D-pdf files. This option gives an opportunity to differentiate from competitors.

3D models created with simulation software are often exported to rendering software to produce high quality pictures or video for sales material.

4.3 Simulation services

Raute's simulation service is aimed at the decision makers of the wood product industry. Mill simulation service can be used in analysis and improvement of existing production systems or design and analysis of new production systems. The objective of the service is to convert customer's data and figures into practical information by simulating mill operations.

The simulation model can be simplified to a configurable mill level component. Figure 1 shows the information flow of Raute's mill simulation concept. Data configuration and reporting are done in external systems and layout configuration and simulation in Visual Components software.

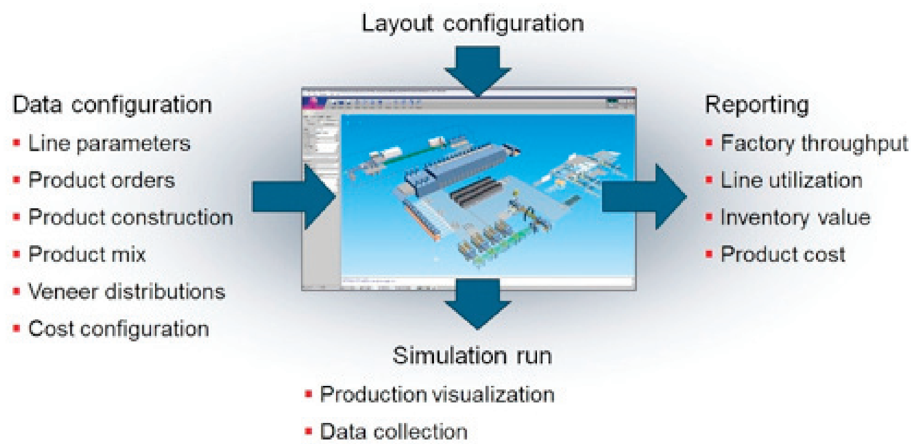

FIGURE 1. *Raute's mill simulation concept.*

Mill simulation can be used to minimize investment risks by testing and verifying plans in advance or test different manufacturing scenarios with quick "what-if" experiments. Mill simulation can also be used for problem solving such as recognizing the bottlenecks of the system or developing a production control system.

5 CONCLUSION

With the simulation tools, practical hands-on learning activities can be carried out and accelerated in a cost effective and safe manner and the dissemination of the state-of-the-art technology between the companies and universities will become more effective. In industrial enterprises the "bottlenecks" of the production systems can be detected and commissioning processes speeded up.

It is also proven that 3D simulation is an effective tool for visual management and a key to effective communication. Here is a list of practical summary of experiences in Raute's simulation activity:

- It provides information for decision making and increases confidence for the chosen concept
- Product and process decisions can be made for multiple perspectives to increase product quality
- Simulation accelerates product development lead time at the concept design stage
- Quality costs are reduced because problems are discovered at an early stage
- Simulation does not need a lot of resources when there are enough standard reusable models and a few competent people to run simulation software

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146 ROCKETING PROFESSIONAL COMPETENCE OF ENGINEERING STUDENTS AT TUAS (TURKU UNIVERSITY OF APPLIED SCIENCES)

Tero Reunanen[1] & Riitta Windahl[2]

1 Turku University of Applied Sciences, Turku, Finland, tero.reunanen@turkuamk.fi
2 Turku University of Applied Sciences, Turku, Finland, riitta.windahl@turkuamk.fi

ABSTRACT

In this paper, the development of professional competencies defined within the curriculum of engineering studies, as well as the requirements related to learning environment innovations, are discussed. Transfer of knowledge related to global business operations in different cultures is of special interest here. In the Rocket project, in the Faculty of Technology, Environment, and Business at Turku University of Applied Sciences (later: TUAS), the network structure for the cooperation between universities and machine technology companies has been developed to support the global business competence development of engineering students. As a result of the Rocket project, the model has been created where the students will learn and train some essential professional competencies needed in global engineering business today. In this conference paper, the model building and the best practises created at TUAS are discussed and shared.

Keywords: Professional training, Knowledge transfer, Industry-university cooperation.

1 INTRODUCTION

Flexibility and ability to smoothly adapt oneself to the constantly changing operation environment are among the most essential abilities needed in global business today. Key competence of the professionals must be tuned accordingly on the regular basis, which creates some extra pressure for the educators of engineers. Operating within a strange culture, and learning production and supply chain management activities abroad are among these valuable competencies. The big question is: How can the future engineering and business competence best be learned and internalized today?

Pressure is also set for the effectiveness of the education. In practice this means that within a shortening period of time the students must be able to acquire – among other things – the knowledge needed in global operations in the future. Elements included in lean philosophy and agility are essential in education, the same way they are essential in any business activity today. Educators should be able to "eliminate all waste" included in the processes during the study program implementation. Furthermore, proactive monitoring of the changes in the operation environment and fast reaction accordingly, are required. Another big question is: How can the anticipated qualities best be provided for the professionals-to-be during the implementation of engineering study programs?

2 DEFINING KEY COMPETENCE – PROFESSIONAL COMPETENCE DEVELOPMENT IN INTERNATIONAL OPERATIONS

In this chapter, the competence defining process is in the focus. No doubt, some basic standard is needed to create global criteria for the professional competence profile for engineers. In addition, the situational elements and future prospects must be taken account.

In engineering studies, CDIO syllabus creates an excellent standard or basic tool package for outlining the competencies. As a standard, it constitutes a global precept for curriculum development at the universities [1]. The CDIO INITIATIVE is an innovative educational framework for curricular planning and outcome-based assessment of engineering education. The concept was originally conceived at the Massachusetts Institute of Technology in the late 1990's. CDIO stands for Conceive — Design — Implement — Operate. If CDIO is seen as a standard of engineering education, the implementation of the education as a process should offer the critical elements of competitive advantage included in the competence profile. Standard in itself can hardly be the core value creator here though it creates a creditable frame.

However, the educator has an authority to make a decision about what should be learned and how. The autonomy of the universities of applied sciences in Finland has been enlarging little by little during the last few years and the process is still going on. For instance, the rest of the universities of applied sciences will be privatized during the year 2013. Besides, the autonomy of a student is steadily increasing, too. Modularity within curricula will be a standard by the year 2013, which aims to increase the alternatives available for students. Though, the modularity in itself will not increase the freedom of choice without some adjustment in the basic processes, e.g. in a traditional timetable institution.

The competence profile related to internationalization and mobility consists of the following items in the CDIO Syllabus v2.0 standard [1]: Communications in Foreign Languages (3.3), International norms (2.5.2 within 2.5 Ethics, Equity and Other Responsibilities), Developing a Global Perspective (4.1.6 within 4.1 External, Societal and Environmental Context), and Working in International Organizations (4.2.5 within 4.2 Enterprise and Business Context).

These sections can be found within the curricula of TUAS where the outcome-based definitions for the anticipated competence are used in all curricula. The competence profiles are formulated based on the field-specific tradition and feedback from the students and organizations in the field in question. For the vision about future needs there are advisory boards discussing the competence requirements with the educator on the regular basis. The advisory board in the faculty of engineering studies consists of the representatives from companies and other organizations closely related to engineering issues. Definition of future needs is the most challenging part in this process of curricula development. Both the students and companies are typically considering their immediate need, not necessarily the needs required in the further than near future. From the educator's point of view, the problem related to curricula is: how can the engineering students best be equipped with the competence required in the international operations in future?

3 KNOWLEDGE TRANSFER DURING THE STUDIES - FROM EXPLICIT TO IMPLICIT KNOWLEDGE

In this chapter, knowledge transfer and development as a social process are considered. The quality of knowledge is also considered using classical division into explicit and tacit knowledge.

Knowledge management is worth mentioning here as an essential part in the development of innovative processes. According to Krogh et al. the goal for knowledge management is to stimulate individuals to do excellent job, and at the same time, to capture their knowledge and transform it into something that an organization can use – like new routines, new insights, new concepts, and so on [2]. Unlike information, knowledge encompasses the beliefs, commitments and actions of individuals and groups, and it consists of both tacit and explicit knowledge. Thus, knowledge cannot be represented in the same manner as information – storing and transforming it in some way is difficult. And especially complicated might be efforts to transfer tacit knowledge. Thus, knowledge creation and transfer have much more to do with relationships and community-building than databases.

Most typically, knowledge is divided into explicit and tacit, where explicit knowledge can be quite easily documented and is not necessarily bound to a certain context, while tacit knowledge is difficult, if not impossible to document, and is always context-bound [3]. Explicit knowledge is the most common type of knowledge learned during the studies implemented in a classroom, e.g. in the form of a lecture. Laboratory experiment added to a lecture includes some elements of tacit knowledge but only after using that knowledge in some authentic situation in practice the knowledge can really turn into tacit one.

Knowledge seen from the process-oriented perspective sets the focus on knowledge sharing in a combination of social interaction and technological transfer [4]. Essential here is the way knowledge is created and transferred via complex processes, and that is why the whole context and background of artefacts are taken account. Further, in the process-oriented epistemology, both explicit and tacit knowledge are included, and by knowledge management these two knowledge types are made to interact. Nonaka and Konno are talking about 'ba', a shared space for emerging relationships that provide a kind of platform for advancing individual and collective knowledge [5]. This space can be physical, mental, virtual, or any combination of them, as far as it can be considered serving as a foundation for knowledge creation. Knowledge separated from "ba" turns into information. According to Nonaka and Konno, "ba" exists at many levels and these levels may be connected with and form even greater "ba" which they call "basho". According to this philosophy, the official structures are getting more marginal and the verifiable results more important within the implementation of studies.

Wenger talks about 'the communities of practice' approaching the issue from the sociological perspective [6]. He describes learning as interplay between experience and competence, taking place in various communities of practice on different levels. These kinds of communities can be found in every organization, mostly as informal small societies distinct from the formal units of organizations, developed around things that really matter to people [6]. Despite the influence of outside constraints and directives, practices developed by members are their own response to that external influence. In this sense, the communities of practice would be quite self-organizing systems with either negative or positive ambitions. But with support and right kind of management it is possible to make them function in a task oriented and innovative way, crossing the organizational and national boundaries. As important sources of knowledge, these communities cannot be neglected when innovative processes are developed.

Considering the knowledge creation and transfer during the studies, the question about the balance between explicit and tacit knowledge gets interesting. How much tacit knowledge should be included, and where tacit knowledge is needed instead of an explicit one? For instance, is explicit knowledge enough in the connection of international skills and operations studies? It can also be wondered which subjects should be included in the basic degree and which topics/ subjects could be taken later as post-graduate studies or to be left to the employers to take care of.

Supposing that competence related to international operations can best be learned in authentic environment, the interesting question is: what kind of activities could increase the popularity and integration of studies within the subject of international skills and operations?

4 PROFESSIONAL TRAINING ABROAD – ROCKET'S MODEL DESCRIBED AND DEVELOPED

In this chapter, the model created at TUAS for the training and studying abroad is first described and then the ideas about further model development are highlighted.

The goal of the Rocket project is twofold; on one hand, the innovative learning environment has been created for the real R&D assignments coming from companies. On the other hand, the basic infrastructure for the practical training periods abroad has been developed in cooperation with globally operating companies, as well as with foreign universities. Statistics about willingness to participate in the exchange programs available for engineering students at TUAS makes some basis. Figure 1 below gives a number of exchange students per country covering the period from 2006 to 2011.

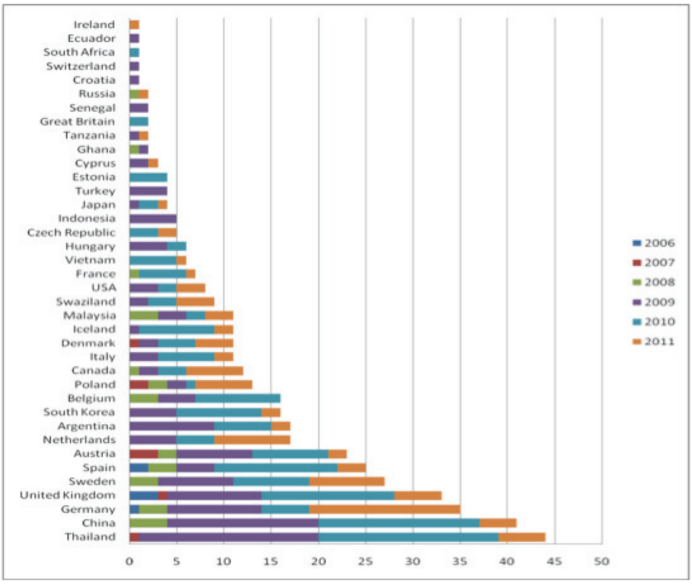

FIGURE 1. *Number of exchange students from TYT by country (by year) [7].*

Here below in Figure 2 it is visualized the amount of engineering students studying abroad some time by participating in exchange programs at TUAS in the faculty of Technology, Environment and Business (TYT in figures). Figure 3 shows the amount of all students At TUAS making some time abroad either by studying or making professional training. The number of students making internship abroad is extremely low – only a few students per year. And in general, the overall number has dramatically decreased after 2009-2010.

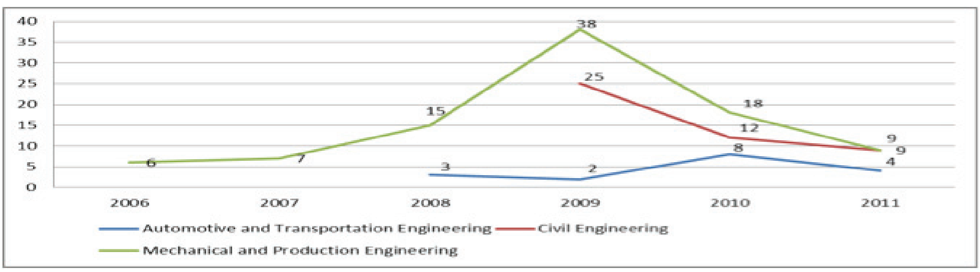

FIGURE 2. *Number of exchange students from TYT/engineering per year [7].*

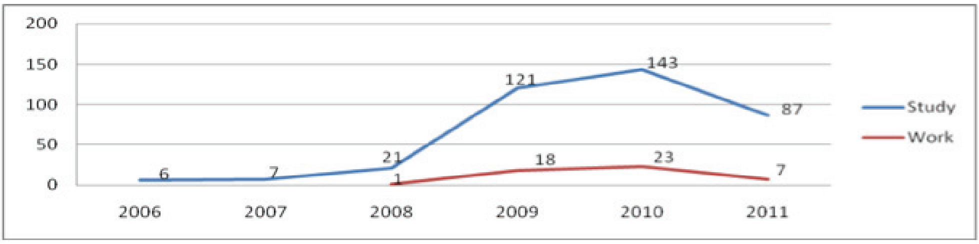

FIGURE 3. *Number of exchange students from all TYT per year [7].*

Based on the statistics given above, it is obvious that some actions are needed to encourage the students to make part of their studies, including internship, abroad. Especially the low number of students making their internship abroad caused worries at TUAS. By sitting in a classroom of a foreign country students cannot internalize or learn much about international business operations. True, the different cultures are getting familiar in that way, too, but it can hardly be enough for professionals-to-be today. According to the theory of tacit knowledge transfer the only way to internalize something about international operations, for instance, is to involve oneself in those activities in practice.

In the Rocket project at TUAS, the network structure for the cooperation between universities and machine technology companies has been developed to support the global business competence development of engineering students and to encourage them to go abroad. Transfer of knowledge related to global production and business operations in different cultures has been of special interest here. To make the cooperation function smoothly between the university, the companies, and individual engineering students, a supporting infrastructure consisting of official operators in both domestic and foreign country has been developed, together with a creation of a mentoring procedure covering the training period.

A pilot phase has been taken place in China where the partner universities take care of the student accommodation and familiarizes students with the new environment and culture, among other things. The cooperation with the partner universities was built up by the Finnish delegations consisting of several high-level officials representing the Finnish system of higher education, Finnish industry and governmental and municipal organizations. The agreements were also made with the Finnish companies operating in China to take engineering students in as trainees for a certain period. First few students have already tested the system and the results are promising thus far. The testing goes on in the autumn semester 2012 when some teachers are joining the system as co-learners and coaches abroad.

Assessing the system based on piloting, some further development must be considered taking different points of view into account. From the students' point of view, internship abroad as a team could be preferred as an attractive option. This would also allow the knowledge sharing within a group and thus add value to the process. Possibilities for personnel involvement in training periods abroad have been discussed, too. That would make it possible to update the knowledge of international operations among the personnel, and at the same time, provide possibilities for personnel exchange and international R&D projects with the partner universities and companies. In addition to that, it might decrease the students' feeling of insecurity related to foreign surrounding.

More integration within curricula is also needed, including separate courses, projects, internship, and final thesis. More integration is also needed within different activities of TUAS, especially between teaching, R&D activities, exchange programs for students, and exchange programs for personnel.

The idea of reciprocity could be further developed at TUAS to be able to offer the same package to exchange students (and personnel) coming here to TUAS. It would be the most practical to use the same kind of procedure at both ends – here in Finland and in the foreign partner university. Apparently, it would make it easier for TUAS to find committed partners around the world.

Productization of the training abroad would probably make it easier to handle both for the students/student teams (added with tutors/personnel representatives) and companies abroad. The whole process must be divided into sub-processes, and all these sub-processes included in the internship must be carefully analyzed, and the package created where all the issues faced by a student and a company abroad are well prepared beforehand. On hand, it clarifies and simplifies the process, on the other hand, from the student's point of view, those ready-made elements weaken the process of tacit knowledge creation here. Preferably, the supporting infrastructure should activate students and stimulate the system at the same time. Some form of mass customization could be a solution.

5 CONCLUSIONS

To be able to increase the amount of tacit knowledge creation during the studies (in relation to explicit knowledge), a growing part of studies should take place in authentic environment, instead of classrooms. For instance, skills related to the international competence profile are hard to internalize by listening to lectures in the home country. The lecture in a classroom of some foreign country does not make a big difference when it is question e.g. about global business operations or offshore production.

The structures at the universities of applied sciences must be regenerated to guarantee the stimulating enough infrastructure for all parties involved in the study units related to the international competence profile in curricula. For instance, more integration is needed in curricula between study units, in different activities and levels, and between people or actors involved. With more integration, the effectiveness of studies can also be improved. Platforms for social interaction and knowledge refinement are essential on every level and for all actors, and thus the infrastructure for the overall innovativeness of the whole system would be upgraded.

Finally, there are more questions than answers in this paper. In a way, it is reflecting the present situation in the field of higher education. Lecterns have been disposed of already and timetables are getting rare. In the system of higher education, we are quite probably going towards apprenticeship-type learning when a growing part of the studies will take place in the authentic environment instead off classrooms and traditional laboratories. Further, no doubt the focus will be shifted more clearly from official structures into real and verifiable results of the education.

6 ACKNOWLEDGEMENTS

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149 LEARNING ADVANCED TELEMETRY AND TELECONTROL SYSTEMS IN THE LABORATORY

Charalampidou Maria[1], S.G.Mouroutsos[2] & George Pavlidis[3]

1 Department of Electrical and Computer Engineering, Democritus University of Thrace, macharal @ee.duth.gr
2 Department of Electrical and Computer Engineering, Democritus University of Thrace, sgmour@ee.duth.gr
3 Department of Multimedia, 'Athena' Research Centre, gpavlid@ceti.gr

ABSTRACT

Driven by the necessity for young engineers to master aspects of advanced technology, this work describes an innovative scheme that has been designed and implemented for teaching advanced telemetry and telecontrol in the laboratory. The scheme gives students the choice to create and test their own scenarios to an entirely parameterized telemetry and telecontrol system that has been installed in a special controlled environment. The core of the telemetry system is a wireless sensor network (WSN), which monitors the environmental conditions of the controlled environment while the control system is complemented by an override subsystem that uses an advanced user interface. Specific laboratory exercises have been designed to be used in this system. The scheme is being evaluated by undergraduate students in Electrical and Computer Engineering and preliminary evaluation results have shown significant acceptance of the system and the concept itself, as it enhanced the learning process with a more engaging approach.

Keywords: Telemetry, Telecontrol, Engineering Education, Human-Computer Interaction

1 INTRODUCTION

During the last century, engineering education has become greater than teaching basic principles and initial aspects of education for becoming an engineer. Working in engineering education, means working beyond conventional methods and systems. In this line, educational research must also cover the field of advanced education and specialization in an efficient way. Modern approaches analyse engineering education using the theory of system thinking and system engineering (worth mentioning here that these modern approaches go back to Greek philosophers and have been a topic of philosophy ever since) [1]. Electrical engineering education can cover from educational research and methods to educational material, programs and technology in order to include all aspects of the field of interest. Other research efforts propose the expansion of curricula to include more educational material, such as engineering entrepreneurship that is believed it could enhance the general education received by students and help them, among others, to understand professional and ethical responsibility, and the need to communicate clearly and effectively [2]. Electrical engineering education should mainly address the needs for young engineers to master technology, to advance, branch out, and be most effective during their careers. At the same time in order to help students familiarize with the advanced technology, traditional and modern methods of teaching have been employed.

Computer-aided interactive multimedia manufacturing coursewares, including audio/video education tools, interactive computer software, on-line assignment and exams and on-line evaluation tools to obtain users' feedback to enhance teaching [3] or other web-based / e-learning applications ([4]-[10]) and also remote or web-based laboratories ([11]-[14]) have been mobilized by educators to meet the ever increasing demands of knowledge, skills, attitudes and competencies.

Despite the general tendency to transform laboratories to virtual experimentation environments, we propose the enhancement of real laboratories with advanced technologies and tools that reinforces the educational and learning process. Similar approaches can be found in [15] and in [16]. Main scope of our laboratory exercises is to teach advanced telemetry and telecontrol using Wireless Sensor Networks (WSNs). The exercises were used as part of the undergraduate course Energy Systems Automation offered by the Department of Electrical and Computer Engineering of Democritus University of Thrace. They consist of three sets of hands-on exercises along with an introductory lecture and the appropriate tutorials including information about: the main goals, the necessary theoretical background (on telemetry/control systems and Human Computer Interaction (HCI) devices), and the laboratory equipment and laboratory software applications. The proposed scheme has been tested in real-life conditions and preliminary evaluation results have been collected and are also being presented here.

2 SYSTEM ARCHITECTURE

The system consists of a telemetry element using a WSN and a telecontrol element accompanied with an interaction device, the data glove (Figure 1). The core of the telemetry element is a wireless sensor network (WSN), which monitors the environmental conditions of a controlled environment. The telemetry element uses the PrismaSense platform that supports the following architecture [17]:

a) Smart sensors as measuring motes (collectors -Quax DT, Quax MS-)
b) Gateway
c) Supervisory and control center

More specifically, the telemetry element collects the measurements of several basic environmental measurements, such as temperature (°C), relative humidity (%), vibrations/acceleration (mV) and light intensity (Lux). These measurements taken from a controlled environment are being visualized and processed on the central control station (the supervisory and control center). The purpose of this WSN is to provide data for the successful automatic management of various devices and subsystems, such as a heating and a cooling subsystem, a humidification and a dehumidification subsystem, along with a lighting subsystem, which have been installed to regulate the controlled environmental conditions. The telecontrol element consists of:

a) A data acquisition card (DAQ)
b) A relays card
c) Various devices in the controlled room

The digital outputs of the DAQ, are used to transmit the control signals to the relays' card that drive the activation of the devices placed in the experimental controlled room. In addition the telecontrol element is complemented by an override subsystem that uses an advanced user interface to help users override the automatic processes. This includes a data glove, a technology taken from virtual reality, which provides the user with the ability to feed override commands using finger gestures. Specifically, the model which is used is a 5DT Data Glove 5 Ultra, with 5 sensors. The data glove provides measurements that correspond to the relative position of each finger, as indicated by the degree of deformation of each finger sensor. In that way, we enrich the approach of telecontrol by proposing the incorporation of advanced human-computer interaction, enabling human intervention to the overall system in a natural way. Thus, the system not only monitors the environmental conditions in the area of interest but also the user. User's finger movements feed the system with information to understand the user's preference.

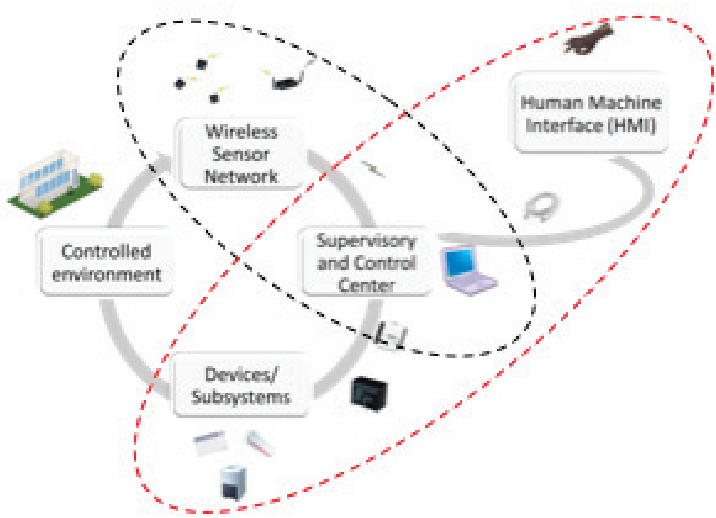

FIGURE 1. *The overall system (black dotted line – telemetry element, red – telecontrol element).*

3 LABORATORY EXERCISES

The goal of the designed exercises is to teach and familiarize students with the process of measurements, the usage of sensors and sensor networks, telemetry, remote control of environmental conditions according to certain scenarios, telecontrol and advanced user interaction for manual control. To meet this goal the laboratory exercises are divided into three sets. The first set is oriented to familiarize trainees with telemetry and remote control. The second set is oriented to expand telemetry systems to telemetry and telecontrol systems and the third set further expands the system to employ advanced human computer interaction. With this expansion the trainee can experiment with manual intervention at any time, directly and most importantly, naturally.

In order to prepare the trainees for the laboratory exercises an introductory lecture is given in advance, covering the basic theory topics, such as: the theory of measurements (accuracy, precision, uncertainty, etc.) and WSNs or the theory of telemetry/control systems and applications, HCI and multimodal interaction devices etc. To meet the needs of the laboratories exercises a specially designed application, named Tutorials have been developed. A brief description of the application along with detailed description of the exercises is given in the following sections.

3.1 Tutorials – the application

The application called Tutorials is designed for the purposes of laboratory exercises. A screenshot of the application is given in Figure 2.

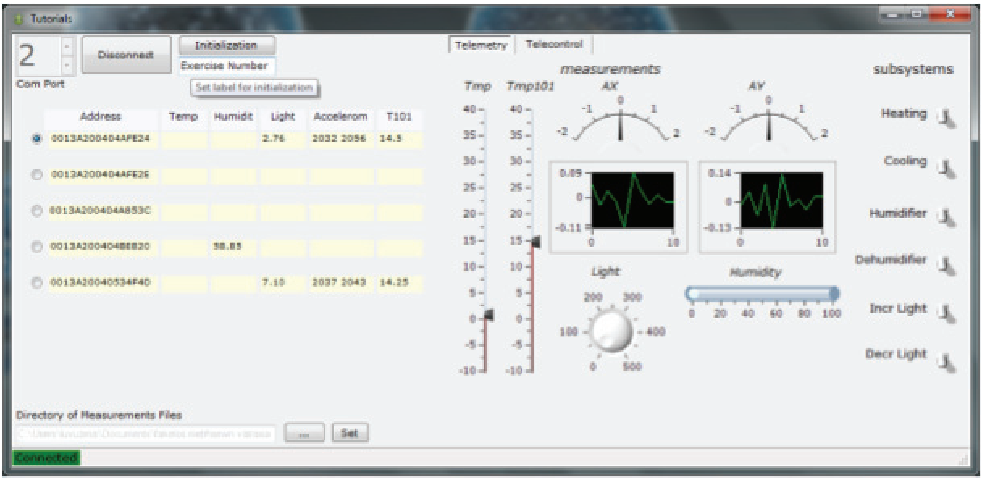

FIGURE 2. *Screenshot of Tutorials, Telemetry tab activated.*

As shown in Figure 2, the application is divided into two sections. On the left-half there is a table of raw measurements. Each row corresponds to a collector (smart sensor) of the WSN and each column is a physical quantity. Every table element corresponds to a measured physical quantity. On the right-half there are two tabs, named Telemetry and Telecontrol. In the Telemetry tab the user can graphically visualize measurements taken from a selected collector. For example, the accelerometer measurements can be visualized in two ways: either by a virtual gauge of the instantaneous values or by a graphical representation of 10 past measured values. Furthermore, the Telemetry tab offers remote control of the devices/subsystems into the controlled environment, by virtual switches.

In the Telecontrol tab (Figure 3), the user can set desired environmental scenarios for the controlled room. In order to do that a collector must be selected and minimum and maximum desired values must be set. The system uses these limits and decides, automatically, which devices and subsystems must be activated. If the desired environmental scenario is achieved, the system deactivates all the devices and subsystems in the controlled room. Moreover within the telecontrol tab the user can select the option Override (Figure 3). This enables the interaction with the advanced HCI device, the data glove, using predefined gestures in order to stop an activated alarm and the corresponding device and subsystem for as long as the user presents the same gesture.

FIGURE 3. *Screenshots of Tutorials, Telecontrol tab activated, Override option selected.*

3.2 First set of laboratory exercises – Telemetry and remote control

The first set of exercises is designed to familiarize trainees with telemetry and remote control. To serve this purpose the initial set exercises introduce trainees to the physical devices (sensors, collectors, gateways, devices/subsystems into the controlled room). The trainees firstly, learn about the equipment and how to physically connect and disconnect sensors to the collectors. Secondly they learn how to program and activate the connected sensors of the collectors. Thirdly they import and export nodes to the WSN, by changing specific system parameters. Afterwards, they measure physical quantities such as temperature, humidity and lighting conditions, and estimate the accuracy, precision and uncertainty of their measurements. Another section of measurements is covered by learning how to measure vibrations and tilt with the accelerometer. Integral part of this exercise is the comparison of their measurements with the ones in the datasheet and the conclusion about the correctness of their results. In the last exercise of this set, trainees are required to implement a certain environmental scenario for the controlled room and manually act on devices and subsystems using virtual switches. Their goal is to achieve the desired environmental conditions and preserve these conditions for 5 min.

3.3 Second set of laboratory exercises – Telemetry and telecontrol

In this set of exercises trainees get familiarized with the automatic control of the devices. Firstly, they get familiarized with the alarms provided by the application, and learn how to set environmental condition scenarios. Accordingly they are required to predict alarms and the activation/deactivation of corresponding subsystems. At the end of this set of exercises trainees set a desired environmental scenario and monitor the measurements and the state of the alarms every minute. Their goal is to monitor the environmental state of the controlled room and how the system automatically achieves and preserves the scenario for 5 min.

3.4 Third set of laboratory exercises – Advanced telemetry and telecontrol

In this set of exercises trainees are introduced to advanced and multimodal HCI devices. In particular they get familiarized with the data glove and learn how and why this device is chosen to be incorporated with the telemetry and telecontrol system, focusing on natural interaction aiming at direct human intervention to an automatic control system. Trainees set their own environmental condition scenario and monitor the measurements from the controlled room along with the state of the alarms, and have the option to manually intervene, using predefined finger gestures.

4 EVALUATION

To evaluate this work, a group of 40 undergraduate students in Electrical and Computer Engineering were asked to perform the laboratory exercises and respond to a questionnaire (Figure 4) about the basic aspects of their experience, which showed a great percentage of acceptance to the system and the concept itself, as it enhanced the learning process with a more engaging approach.

1.	Do you think that the laboratory exercises that you are going to attend will be interesting?
2.	Do you think that you are familiarized with HCI devices?
3.	Do you think that you are familiarized with the field of measurements?
4.	Was *Tutorials*an easy to use application?
5.	Do you think that the questions of the laboratory exercises serve their goals?
6.	Did you find difficulties to answer the questions of the laboratory exercises?
7.	Do you think that this laboratory was interesting, comparing to other laboratories?
8.	Do you think that this laboratory was useful, comparing to other laboratories?
9.	Do you think that the presence of a trainer is necessary?
10.	Do you think that you got familiarized with the field of measurements?
11.	Do you think that you got familiarized with the field of HCI devices?
12.	Do you think that this laboratory encourages you to be involved with telemetry and telecontrol systems?
13.	Do you think that this laboratory was interesting?
14.	Do you think that this laboratory was useful?
15.	Are you pleased with the laboratory philosophy and setup?

FIGURE 4. *The questionnaire.*

The responses and feedback from students served not only to evaluate the performance of the proposed experiments in adding to the students' learning process, but also as feedback for future fine-tuning of these modular experiments as pedagogical learning tools. The trainees where asked to answer according to a scale ranging from 1 (very negative) to 5 (very positive). Finally, taking into account that one of the main goals of the laboratory exercises was the familiarization of undergraduate students with new technologies, Table 1 summarizes the overall distribution of the results in percentage of ratings for every question and indicates a general positive view of the overall experience. Also, Figure 5 presents some interesting evaluation graphs, depicting in (a) the overall acceptance of the system in terms of a boxplot with ratings being the categories, and in (b) and (c) the shift in acceptance before and after the exercises, as indicated by the paired questions 2-11 and 3-10 (see Figure 4).

Table 1: Percentage of ratings for every question.

Questions	Counts on Ratings					Questions	Counts on Ratings				
	1	2	3	4	5		1	2	3	4	5
1	3%	3%	18%	23%	**55%**	**9**	0%	3%	10%	23%	**64%**
2	10%	20%	**40%**	28%	3%	**10**	0%	3%	5%	44%	**49%**
3	0%	5%	**55%**	35%	5%	**11**	0%	0%	10%	36%	**54%**
4	0%	0%	3%	**51%**	46%	**12**	0%	3%	5%	36%	**56%**
5	0%	0%	5%	44%	**51%**	**13**	0%	0%	3%	28%	**69%**
6	18%	**38%**	21%	18%	5%	**14**	0%	3%	3%	**54%**	41%
7	3%	0%	5%	36%	**56%**	**15**	0%	0%	0%	28%	**72%**
8	0%	3%	8%	28%	**62%**						

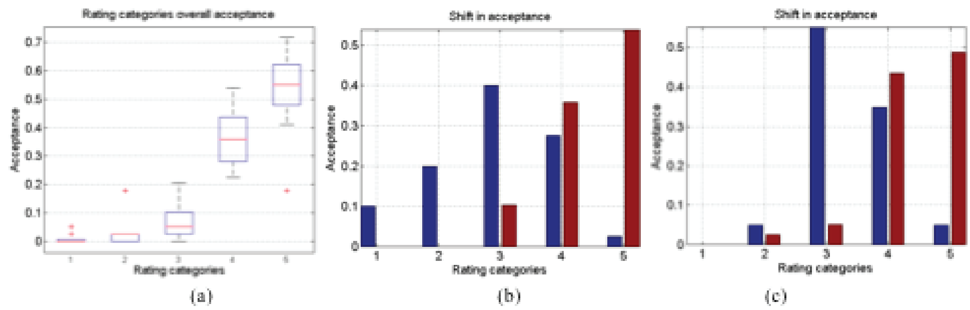

FIGURE 5. *Evaluation results: (a) overall acceptance of the methodology, (b),(c) shift of acceptance in questions regarding before and after the exercises.*

5 CONCLUSION

This work presents an effort to enhance the learning process by proposing advanced laboratory exercises that aim to familiarize trainees with telemetry and telecontrol, using smart sensors, a DAQ and a data glove. The trainees through three sets of exercises learn how to setup a sensor network, to activate and deactivate smart sensors, measure basic quantities, remotely control devices and subsystems and interfere to automated operations exploiting advanced human computer interaction. The preliminary evaluation results show that such a system and methodology is highly accepted, a fact that urges us to enhance it even more by increasing the number of smart sensors and the types of physical quantities that can be measured, in addition to even more sophisticated human-computer interaction systems.

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150 EVOLUTIONARY APPROACH TO MODERN CREATIVE ENGINEERING STUDIES IN TURKU UNIVERSITY OF APPLIED SCIENCES

Tero Reunanen[1], Juha Valtanen[2] & Windahl Riitta[3]

1 Turku University of Applied Sciences, Turku, Finland, tero.reunanen@turkuamk.fi
2 Machine Technology Center Turku Ltd, Turku, Finland, juha.valtanen@koneteknologiakeskus.fi
3 Turku University of Applied Sciences, Turku, Finland, riitta.windahl@turkuamk.fi

ABSTRACT

This conference paper is a work on defining and discussing the evolutionary approach to the analysis of the creative training of engineers. In the modern, continuously changing world, competencies for students and experts in different fields of engineering are in a constant pressure for re-evaluation and development. Special skills and competencies that were founded even few years ago are in threat to be obsolete. Another challenge, that especially universities of applied sciences (later: UAS) are facing, is that companies where most graduates are going to work have to adapt themselves to more rapidly changing business environment. Competencies which are needed in future situations are hard to foresee. This makes a big challenge for UASs which are trying to answer these requests for new skills with their curricula. Proactive, concrete cooperation between UAS, research and technology centers (later: RTC) and companies is answering this challenge. We argue that evolutionary reasoning or approach could be a future framework of creative training in engineering or other natural sciences.

Keywords: Curriculum development, Industry-university integration, Engineering education.

1 INTRODUCTION

Structural changes in business operations and operation environment in Finland and many other European countries during last decade or so particularly, have clearly proved the need for regeneration of the technical education. For instance, increased rate of outsourcing activities, lengthening supply chains, and globalizing industrial production are among these big changes we have faced here. At the same time, the need for a career extension at its both end is discussed all over Europe, and outside Europe, too. The educators should answer these new challenges by offering updated programs with effective implementation. Request for different types of experts needed now or in the near future should be answered. For this, UASs will need more flexible and more industry- integrated curriculums, resources and facilities. A lot has been done already. For instance, CDIO syllabus has been developed to serve as a global standard for engineering education [1]. On the local level in Finland, increased autonomy has been given to UASs to organize their education, and outcome-based, modular curricula have mostly been taken in use to widen alternatives available for the students. Also, the cooperation with the working life has been purposefully tightened. Nonetheless, some more effort is needed to integrate processes between UASs, RTCs and companies to improve the sensitivity of the curricula development. Furthermore, deeper environment monitoring might be helpful in future needs forecasting.

The basis of the evolutionary analogy is on the classic theoretical analysis of evolutionary economics where focus is – instead of basic Darwinian biological processes – on markets, the routines of firms, path dependence and bounded rationality [2]. Evolutionary theories are comprehensive and it is common to evolutionary analogies that theories have to be dynamic, they deal with irreversible processes and they cover the impact of novelty as the ultimate source of self-transformation. Theories of wholly or partially self-organizing regulatory systems have increased in number and are used in most fields of science now. Within systems theory especially, the regulatory systems have been developed, and in general, they are systems equipped as to stabilize those parameters and processes that are necessary to its existence. Self-regulating systems then, are systems that are self-correcting itself through feedback, and such a self-correcting system can be called self-organizing if the system dynamics promotes certain processes within [3]. In the field of education at Finnish UASs, the use of a framework like this has been rare, partly because of a tradition of a strong state control, partly because of the ossified attitudes at the UASs.

Learning as well as economic interaction are social and dynamic processes. The individual's process of learning and creative work is often characterized by the significant degrees of cumulativeness, disequilibrium situations and path dependence but they may also be determined by the exogenous factors, e.g. curricula. The processes of change occurring in a context of industry and UAS are non-deterministic, non-linear and open-ended. The fact that open-ended regulatory processes are included in all evolutionary systems makes the evolutionary theory especially interesting in this connection [3]. Can this analogy be used when it is talked about the development of curricula and learning environments? The whole evolutionary process is like an open-ended ascent of regulatory control. According to this view, the definition of "truth" would quite certainly close the loop, and that is why there cannot be any definitive "truths" beyond critical assessment in this kind of system. Also, the whole cognitive system should be kept open-ended [3]. Pantzar is talking about the autocatalytic loop feedback cycle where one item in the system catalyzes another item with positive consequences to the whole system [4]. The question is: what kinds of structures or activities are needed to keep the system open-ended in order to guarantee a continuous self-transformation process with positive results?

2 COMPETENCE REQUIREMENTS ON THE MOVE

In this chapter, the competence requirements of engineering studies are in focus. In addition to evolutionary analogy, elements related to futures research and systems theories are used as idea generators here. The topic is discussed from different perspectives: a UAS as an educator to offer study programs, a student as a customer to acquire education, a business company or other organization as a customer's customer to recruit professionals graduated. Another way to see a customer would be to classify students as "products" and recruiting organizations as "customers". But we use here the first mentioned way and talk about students as "customers", which sounds somewhat more human.

Traditionally, the educators decide the goals of the program based on the prevailing field-specific competence tradition, added with a guesstimate of the future needs in practice. Success is then assessed by comparing the goals with (mostly) quantitatively measurable results, like the number of graduates or drop-outs, time spent with studies, and so on. Though, some validity problem might occur if the success of the education is assessed only by comparing the quantitatively measured results with the goals set at the beginning of the studies. Undoubtedly, more qualitative indicators are needed to measure and assess the success of education. Besides, the changes in operation environment might have caused some pressure for tuning the goals all the way during the studies. And the goal setting in itself might be imperfect or skew altogether.

Let us think about the education as a "process" here: If we lock the elements of the process result beforehand in the early state of the process, we hence deny the possibility for a change and for the natural evolution of the system over the process. As a result, we might get exactly what we wanted at the beginning, but does it measure up the needs of the present situation anymore? The challenge here is the ability to manage and maintain the optimum level of variety and uncertainty in the process, so that it is not turning into anarchy. And by anarchy, we mean the system beyond any control.

Talking about curriculum content, some subject or competence is in or out using traditional bivalent logic. According to bivalent logic, something is either "true or false", "in or out", "on or off" [5]. The problem most educators are facing is the fact that the amount of credits included in a certain education is limited. At the same time, requirements of the qualities demanded are increasing, which makes it necessary to drop off some topics while take some new ones in. Thus, the topics are "in or out" of the curriculum. Another problem comes with the adjustment of a curriculum. The yearly checking of the curriculum content is valid for the new students, but not for the old ones which have to go on their studies according to the curriculum locked for them at the beginning. So the perspective used in adjustment is typically related to the study program, not to the needs of a customer or customer's customer.

Figures 1-4 below here describe the competence evaluation related to curricula development. The basic situation is visualized in Figure 1 where the competence profile consists of six competence sectors, each having value 10 in the scale of 0 to 10 (0 in the centre). In the situation in Figure 2, the importance of the competence sector A (upper one) has increased while the importance of the competence sector D (lowest one) has clearly decreased.

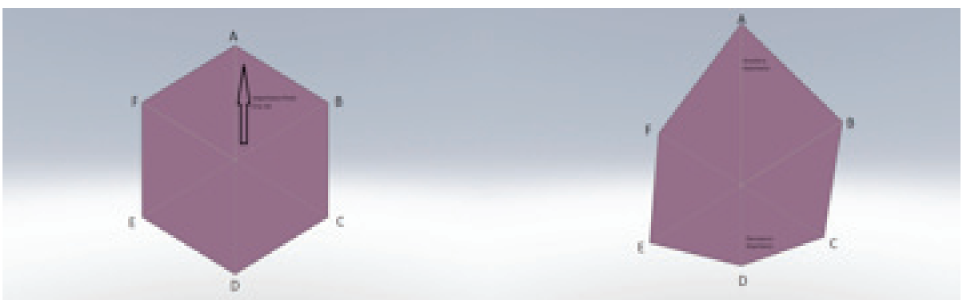
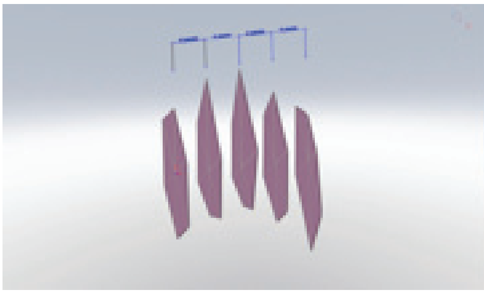


FIGURE 1. **FIGURE 2.**



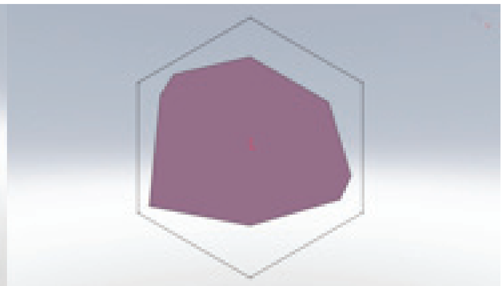
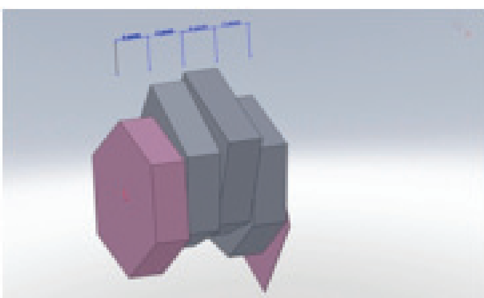


FIGURE 3. **FIGURE 4.**

The changes in the whole competence profile during the period of 16 years are visualized in Figure 3. Each slice covers a competence profile of a four-year period used in curriculum from a single student's point of view. The different shape of five slices tells about the changes in competence profile definition. (There should be a new slice after each competence profile updating affecting the curricula, but here the four-year period is used.) Figure 4 makes a synthesis of the period of 16 years by taking a minimum level from each competence sector, and thus giving some idea about the long-term, field-specific core competence requirements. For instance, competence defined in the sector E has a high average rate telling that it has been ranked as import one during the each 4-year-period within 16 years of inspection.



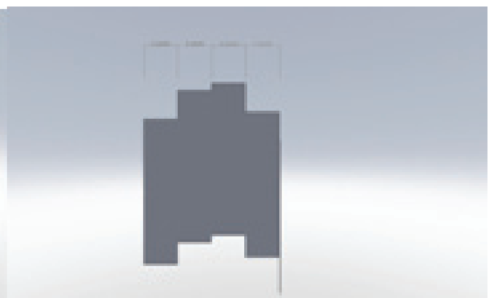


FIGURE 5. **FIGURE 6.**

In Figures 5 and 6 above here, a rigid competence profile is visualized. From a single student's point of view, this describes the situation if the adjustment during the studies cannot be done. Typically, the competence profile defined at the beginning of the studies is not equal with the latest requirements redefined at the end of the studies, and a student graduates with – at least partly – obsolete competence profile. That could be avoided with an adjustable enough curriculum.

Interesting metaphor can be found in the so called railway thinking. According to it, using firmly fixed rails the train will certainly and (mostly) safely end up to the one and only predetermined destination, no matter the need for changes during the trip [6]. The only way to revise the plan is to jump off the train somewhere between a starting point and a final destination. Going further with this railway metaphor, an interrail ticket instead of a one-way ticket from place A to place B would no doubt be a better pick. With some more tracks and change options, the destination choices will increase in number. But even though, the routes and destinations are strictly numbered and quite easily predictable beforehand.

The different solution might be found using multi-valued logic where the elements of the system can be both in and out at the same time. How much in or out some element is, depends on the situation at hand. For instance, in fuzzy systems this multi-valued logic is used [5]. A classic example is a paradox included in the definition of "bald". How much – or few – hair must one have to be called "bald"? At which point can one be called "bald"? The exact definition is quite challenging using bivalent true-or-false -logic. But using multi-valued logic, the solution is easy: there can be different states or grades of "baldness" and the definition of "bald" is flexible, changing with the situation at hand. Another classic example of multi-valued logic where the reactive, proactive and self-organizing system is using fuzzy logic is an intelligent elevator which is constantly adjusting its operating system, based on the data collected about the use of that elevator.

What would the analogy of multi-valued or fuzzy logic mean in the world of education? The content of a curriculum would be constantly adapted to the situation and the needs of the customers and customers' customers taken account. The topics and contents could be taken in or out of the personal study plans without heavy bureaucracy included. Also, to be able to fast enough adjust the overall content of the curriculum, a comprehensive sensor system measuring the trends and weak signals within the operating environment should be included. Because of a time span of four years, it must be looked beyond the present customers and customers' customers, and beyond the needs of today [7]. Asking only the customers' opinion about the future needs, the educator sets its own innovative development in jeopardy. At least some of the resources must be allocated to future operations development, no matter the needs of the present customers.

As a part of that above mentioned sensor system, working methods like utopian thinking can be used to find the gaps between prevailing and desirable situation. In the utopian thinking, it is first defined the most idealistic situation which typically includes unsatisfied needs and requirements which are considered as desirable in the future, but so far, non-existent ones. Completed with a dystopian thinking – where the worst future situation is defined – a kind of catalogue can be created about the shortcomings of the present situation in focus [6]. All the attempts to eliminate or abolish the shortcomings defined can be considered as efforts to develop the present situation towards a better and ideal one. In the connection of curricula, this would mean a possibility for individually tailored paths within a certain frame as a basis. It is just this "frame" that constitutes a challenge here. But in any case, the more diversified the competence requirements are getting, the more freedom there should be included within the frame given in curricula – without losing sight of the overall, field-specific competence requirements.

3 APPROACHES TO FLEXIBLE AND AGILE IMPLEMENTATION

In this chapter the possibilities for more flexible and agile implementation of curricula are discussed considering tolerance to instability and disorder in the system.

How much variability or uncertainty is tolerated within curricula? In a way, it is question about order versus disorder, or stability versus instability of the system. Even though completely stabile systems are rare, the significance of instability in systems is mostly dismissed. In fact, the stabile system should be taken as an exception and something to avoid because of its nature of stagnation [8]. Instead, chaotic systems represent reality and movement, though the direction of movement could be hard to foresee. Chaotic system can be defined as an unpredictable system with chance and coincidence strongly shaping the result of the system [9]. In a chaotic system, the results of different processes are not predictable at the beginning of the processes. According to Laszlo, chaos is not the opposite of order but its refinement – the subtle, complex, and ultrasensitive form of order. Within a separate process, there are numerous internal and external variables involved that might by chance have different states or values, and thus radically shape the final result.

As an open and complex system with different levels and sub-systems, the chaotic system gets continuously energy, impulses and information from its environment, which creates a constant need for adjustment and thus, tension within the system. Tension might be slight or stronger, and it is this tension that makes the system bifurcate and move into a new state. Development of a system comes to reality with these small and bigger bifurcations. In the world of education, different levels and operators of the system can be viewed as micro or sub-systems. For instance, a single student forms a micro system with its own path formulated at the beginning of studies. The question is: can the tension faced by a student as a micro system be realized and reshaped the path in the course of studies?

In general evolution theory, the focus is in the behaviour, maintenance, and self-transformation of complex emergent systems of interacting connected components, whereas in socio-economic evolution theory the focus is in the interaction of processes generating variations (e.g. innovations), transmitting variations through time and space (e.g. learning and imitation), and restricting variations (e.g. selection because of competition or cooperation [3]. General evolutionary theory has also focused on increasing the complexity of systems and understanding about nonlinear systems. But regardless of system nonlinearity, there are typically regulative mechanisms included in the most social systems, too, not only chaotic ones. These regulative mechanisms possess a tendency to restrict the consequences of micro level chaotic elements on the macro level, and thus function as disincentives to the free movement of the system. Using this analogy, the challenge from the educator's point of view is to define these regulative mechanisms affecting the system movements on different levels and in different sub-systems.

4 CONCLUSIONS

With continuous and agile adjustment, it is possible to keep curricula more updated and at the same time, to guarantee the desired competence profile to students. For this purpose, in addition to flexible curricula, a smooth cooperation is required between teaching and R&D activities within UASs. Courage is needed to take new and often random challenges, as well as ability to tolerate uncertainty and disorder around. Figure 7 below here visualizes the situation where the curriculum has been continually adjusted based on the identified need for change in the competence profile. For instance, it could be question about modifying single courses or whole modules based on the real need coming from the operation environment. Not any high “steps” can be seen between the different versions of a curriculum – the adjustment processes has been smoothly taken place, allowing the different competence sectors to float based on the situational need.

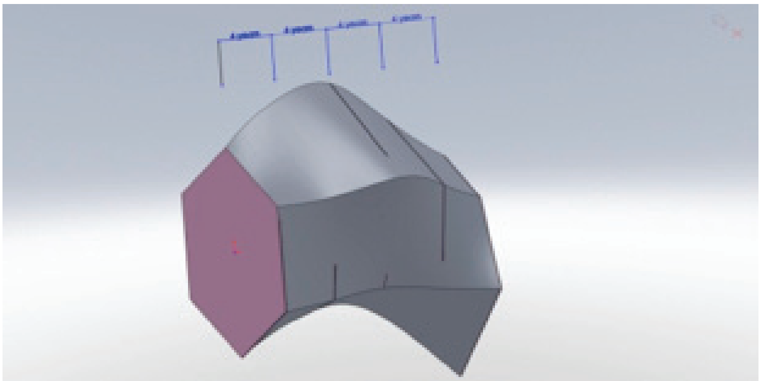


FIGURE 7.

The main value here comes from integrating everyday processes between the universities of applied sciences, research and technology centers and companies towards more cooperation, and working together, for instance, in a joint product or business development cases. With this combination huge benefits for all partners can be achieved and answer for real needs can be guaranteed. This cooperation should be divided at least to two different levels. For distant future needs (long perspective), there should be permanent processes to evaluate into which direction the evolution of technologies and businesses is going. These processes are constantly verifying that strategies are re-evaluated and changed in time. Answering the near future needs (short perspective) the educators face is where selective, analogical evolutionary epistemology can be used in the development of teaching methods and learning environment. One of the key issues here is the open-end nature of the cognitive processes related to environment monitoring, which includes, among other things, the avoidance of bivalent logic with true-or-false mentality, and thus, allows even quite radical individual adjustments based on the prevailing situation – without losing sight of the field-specific core competence.

5 ACKNOWLEDGEMENTS

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151 MAPPING OUT GLOBAL COMPETENCES: A COMPARATIVE CASE STUDY

Kalliopi Skarli[1,2]

1 Turku University of Applied Sciences, Turku, Finland, poppy.skarli@turkuamk.fi
2 Institute of Migration, Turku, Finland, kalska@utu.fi

ABSTRACT

Global competences play an increasingly significant role in the shaping of engineering education as engineering graduates have to compete on a global level. This paper maps out the skills that Information Technology students at Turku University of Applied Sciences perceive they have in their first year of studies and compares three different groups of students, a Finnish and an international group of first year students as well as a mixed nationality group of older students who have completed their Work Placement acting as a control group. A quantitative survey was constructed and the competences were assessed with a 5-point Likert scale. Nine competences were examined in this paper. The first year student display similar levels of competences with variations in teamwork, time management and project skills. The paper concludes with suggestions for curriculum development.

Keywords: global competences, Finland, Information Technology, international students, University of Applied Sciences.

1 INTRODUCTION

Since the early 1990s the world has been experiencing technological, geopolitical and economic changes that have instigated the globalization of engineering education policy and practices. Examples of these changes include the use of the Internet, mobile phones, video conferencing, the collapse of the communist regimes, the establishment of the European Union, the emergence of tiger economies and free trade bilateral agreements. In other words, these changes have made the world more interconnected and interdependent, more like a network instead of cells with little interaction. Location and national borders are not a limitation and it is, for instance, quite possible for an engineer to live in Finland and work for a company with headquarters in the USA, operating in three continents and outsourcing in Vietnam. It is also highly likely for engineers to work in multicultural, multidisciplinary and matrix teams. When developing engineering education, this implies that, in addition to technical skills, engineering graduates need to develop skills or competencies that will enable them to operate and compete on a global scale. This paper aims to map out and compare the competences that 1st year Information Technology students at Turku University of Applied Sciences (TUAS) perceive they have in their first year of studies.

2 GLOBAL COMPETENCES

In general educational terms, the concept of global competences encompasses intercultural competence, that is, world knowledge, foreign language proficiency, cultural empathy, approval of foreign people and cultures, and ability to practice one's profession in an international setting[1]. Global competences also incorporate the concept of "a globally competent learner is one who is able to understand the interconnectedness of peoples and systems, to have a general knowledge of history and world events, to accept and cope with the existence of different cultural values and attitudes and, indeed, to celebrate the richness and benefits of this diversity"[2]. In terms of engineering education global competences contain ideas such as global citizenship, ability to work in global teams and develop and manufacture products for a global market [3]. Downey et al. [4] define global competence as "having the knowledge, ability, and predisposition to work effectively with people who define problems differently than you do". In his study in 2009 Parkinson [5] defines 13 attributes of global competences in engineers. Based on a sum of the rankings by representatives of universities, companies and government, the five most important attributes of global competence are that engineering graduates: a. can appreciate other cultures, b. are proficient working in or directing a team of ethnic and cultural diversity, c. are able to communicate across cultures, d. have had a chance to practice engineering in a global context, whether through an international internship, a service-learning opportunity, a virtual global engineering project or some other form of experience and e. can effectively deal with ethical issues arising from cultural or national differences.

The increasing significance of global competences plays in the reshaping of engineering education is demonstrated in three different ways. Firstly, accrediting agencies incorporate global competence assessment criteria in their evaluations. In the USA, the Accrediting Bureau for Engineering and Technology programs (ABET) expanded its expectation of skills required in graduates of accredited engineering programs by adding "soft skills" in Criterion 3 of the ABET 2000 guidelines[6]. These are: ability to function in multidisciplinary teams, ability to communicate effectively, the education necessary to understand the impact of engineering solutions in a global and societal context, knowledge of contemporary issues.

Secondly, the industry demands global competences because the ways of working are changing and ICT developments have been at the root of such changes. According to a recent report [7] commissioned by the Confederation of Finnish Industries EK, students should be educated to become workers in global companies, to work in matrices and networks even if they would not end up working in them. The report emphasizes the importance of interaction skills and network skills, the ability to apply technology in addition to fluent English as well as languages spoken in emerging markets in Asia and South America, i.e., Russian, Portuguese, Chinese and Spanish.

Thirdly, educational policy is dynamically reshaped to meet the demands of the global labour markets. For example, the Lisbon Strategy aims at making the European Higher Education Area and the European Research Area more visible and competitive in the world and it also marks the shift from national to EU common educational policy [8]. Europe has long recognized that graduates need to be able to function in several European languages and cultures by promoting and supporting EU academic mobility programmes, such as ERASMUS. In conclusion, the above examples from accrediting agencies, industry and education demonstrate that global competences are on ascendance and they are here to stay.

3 METHODOLOGY

Three groups were compared: a group of 1st year Finnish students, a group of 1st year international students and a mixed nationality group of "experts", that is, 2nd, 3rd, or 4th year students who had completed their Work Placement. The "experts" are used as a control group which is representative of the student population. A quantitative survey questionnaire was constructed. The first part collected demographic information and the second part contained 33 "can do" statements. The competences were assessed with a five-point Likert-type scale, with responses ranging from "Disagree Strongly" to "Agree Strongly". The theoretical framework for the competence statements was based on the Evans [9] "starfish" model of competences which includes competences related to content, attitudes and values, learning, methodological and social and interpersonal competences. This model was chosen because it provides a framework for the different types of competences. The model was developed to include linguistic and intercultural competences. The statements measuring intercultural competence were borrowed from Bennett and Hammer's the Intercultural Development Inventory [10]. A hard copy of the questionnaire was personally distributed to the students over 4 days. The respondents were in total 85 students: 47 Finnish students, 28 international students and 10 "expert" students. The response rate was 84% and 96% for the Finnish and international students respectively.

4 RESULTS AND DISCUSSION

4.1 The Student Profiles

Both the Finnish and the international first year groups consisted of predominately males (85% and 86% respectively) in their early 20s. The vast majority of Finnish students came from Turku and the Finland Proper region to which Turku belongs (43% and 34% respectively) and only 23% came from a different Finnish region. All the Finnish students had completed their secondary education in Finland and their families live in Finland as well. In their majority (85%) these students had previous general work experience in Finland. Of those with work experience only 2% had work experience outside Finland and 20% had field-related work experience.

The international students were of nine different nationalities and respective mother tongues. In their overwhelming majority, they came from Asia (82%), Europe (7%), Africa (7%) and North America (3%). None of the international students had completed their secondary education in Finland and the majority of them (97%) had lived in Finland for less than a year. Only 15% of the international students had family or relatives in Finland. As for previous work experience, only 36% of them had worked before. Of those respondents with work experience, 30% mentioned that this experience was general and 40% and the rest did not mentioned what kind of work experience they had. Their work experience mainly took place outside Finland (90%).

When asked about their future plans after graduation, half of the Finnish students would stay in Turku (51%) or in Finland (56%) after graduation. On the other hand, only 11% of the international students would stay in Turku and 18% would stay in Finland. Concerning their career plans, the students were given a list of nine choices (Fig.1) and were asked to select as many choices as they would consider. The majority of Finnish students would see themselves working for an IT company (79%) whereas the international students tended to select further studies abroad (50%) followed by working for an IT company (46%).

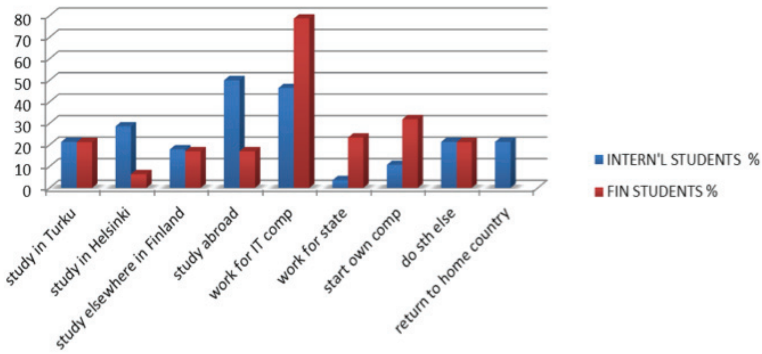

FIGURE1. *Where do you see yourself after completing this degree?*

A clear picture emerges out of the student profiles. On the one hand, there is young, mainly local male group from a single culture. This group has already acquired at least general work experience and is strongly focused on obtaining a job in the IT field after graduation. It is worth mentioning here that one third of that group would consider starting their own company as a career path. On the other hand, there exists an equally young and mainly male group of different cultures. This group has less work experience and is more inclined to pursue further studies after graduation. A win-win situation for both groups would be for the Finnish group to interact with the international group in order to enhance intercultural competence and for the international group to acquire work experience or opportunities that could count as work experience as well as enhance their awareness of the local culture.

4.2 The Student Competences

This paper examines the following 9 competences: understanding of the need for lifelong learning, ability to handle constructive feedback, teamwork skills, interpersonal skills, time-management skills, project skills, networking skills, operating in a foreign language and intercultural acceptance/adaptation. Table 1 compares the competence means across the three student groups.

TABLE 1. Comparison of competence means across the three student groups.

Competences	INTERNATIONAL STUDENTS			FINNISH STUDENTS			EXPERTS MIXED NATIONALS		
	Mean	N	SD	Mean	N	SD	Mean	N	SD
Lifelong learning	4.59	27	0.844	4.47	47	0.804	4.9	10	0.316
Handling feedback	2.7	27	1.137	2.91	47	1.08	2.9	10	1.197
Teamwork	4.07	28	0.716	3.5	46	0.863	3.6	10	1.075
Interpersonal skills	3.93	28	0.858	3.7	47	0.832	3.8	10	1.135
Time management	3.64	28	0.78	2.98	47	0.921	2.9	10	0.738
Project skills	3.81	27	0786	2.91	47	0.88	3.22	9	0.833
Networking skills	3.75	28	0.799	3.37	46	0.645	3.80	10	0.632
Operating in a foreign language	3.61	28	0.994	3.32	47	0.935	3.7	10	1.16
Cultural acceptance /adaptation	4	28	0.72	3.49	47	0.748	3.8	10	0.789

Lifelong Learning: All three groups of students agreed or strongly agreed that in the field of IT there is a constant need to update skills. The expert group was much more aware of this need as they had the highest mean and the lowest standard deviation. This result was expected especially since IT is a field of rapid development.

Handling feedback: All groups tended to disagree that they get upset and sometimes offended when they receive critical feedback. However, the standard deviations across groups were higher than 1 point. Figure 2 shows that some students (international students 26%, Finnish students 32% and experts 10%) strongly agreed or agreed that they become upset. The ability to handle feedback plays an important role in teamwork especially in a global context and is worth investigating further.

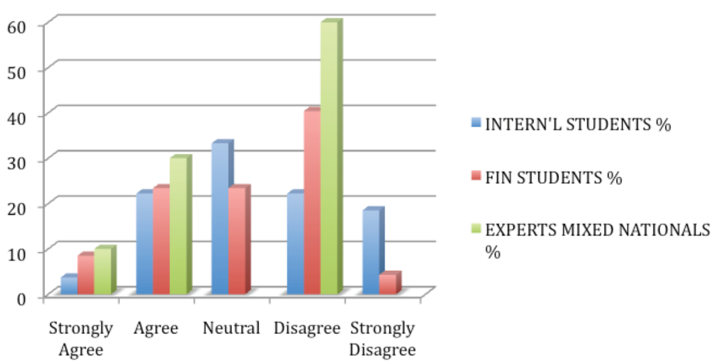

FIGURE 2. *I get upset and sometimes offended when I receive critical feedback.*

Teamwork: The Finnish group and the experts tended to agree whereas the international group agreed that they are good at sharing their knowledge and skills with others and that they are open to their input. However, it is interesting that the experts had the lowest mean and greater standard deviation of the three groups and that the international students had the highest mean. This could be attributed to the fact that international students come from collective cultures and are used to working together.

Interpersonal skills: All groups tended to agree that they have good people skills and that they are good listeners. The international group had the highest mean. The Finnish and the international group standard deviation was less than 1 point. Surprisingly, the expert group had a standard deviation more than 1 point and the lowest of the three means.

Time-management skills: The international group tended to agree that they knew how to divide their time between various work duties and separate work from leisure. This is an interesting result because the sense of time is perceived differently by various cultures and further investigation would be needed for this perception. However, the Finnish and the expert group were uncertain about these skills. The expert group had the lowest mean which is quite surprising as these students have theoretically more experience in balancing their work and leisure time. Nevertheless, if one uses computers for everything, the borders between work and leisure may be blurred.

Project skills: The international group and the experts tended to agree that they could plan and execute tasks according to schedule and strive to achieve goals whereas the Finnish groups was unsure of that. Once more, the international group mean was slightly greater than the expert group. Here there could be two possible explanations: a. that the international students are more clear about what their goals are or b. that they have tended to overrate their competence.

Networking skills: All groups tended to agree that they understood the significance of networking and knew how to create and maintain their network of contacts. As expected, the expert group had the highest mean with the smallest standard deviation.

Operating in a foreign language: All the groups tended to agree that they are good at working with people using a language other than their mother tongue. The experts had the highest mean but also a standard deviation of more than 1 point. The means of the Finnish and the international group were of similar levels. This could be explained by the fact that for the majority of the international students, English is a foreign language that they have to use in a third country, Finland, where they have only been for less than a year. On the other hand, the Finnish students read part of their study material in English and have acquired English skills from their secondary education. However, the degree of confidence of working with people using English might account for the larger standard deviation in the expert group.

Cultural acceptance/adaptation: The international group agreed that they can evaluate situations in their own culture based on experience and knowledge of other cultures while the other two groups tended to agree. This result was expected since the international students live and study in a foreign country in addition to being members of a culturally diverse group.

5 CONCLUSION

This paper aimed to chart the global competences 1st year Finnish and international Information Technology students in Turku University of Applied Sciences perceive they have. These competences were compared to those of a control group of "expert" students. Nine competences were examined in this paper. Both the Finnish and the international group rated themselves on similar levels of competences. In project skills the international group mean was 1 point higher than the Finnish group. This survey was a quantitative survey and a qualitative survey would be required for further analysis.

Based on the results of this survey, the following curriculum developments are suggested:

a. Developing a joint course or series of workshops for both groups of students in their first year of studies could be used as a mechanism for developing intercultural competence.
b. Tutoring could include a workshop on handling feedback, exploring the reasons why feedback is given, how it is given and cultural awareness when giving and receiving feedback.
c. The concept of teamwork could also be explored. For example, how teamwork is perceived in different cultures and how is it perceived in the context of a project.
d. A time-management simulation game could be developed to enhance this competence. The game could incorporate how the sense of time is perceived across different cultures.

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152 CREATION OF QUALITY ASSURANCE IN LIFELONG LEARNING IN THE SLOVAK REPUBLIC

Mária Rostášová[1], Tatiana Corejová[2] & Alena Chrenková[3]

1 University of Žilina, maria.rostasova@fpedas.uniza.sk
2 University of Žilina, tatiana.corejova@fpedas.uniza.sk
3 University of Žilina, alena.chrenkova@fpedas.uniza.sk

ABSTRACT

The article deals with current situation in the Slovak Republic in the field of quality assurance of lifelong learning. Despite the fact that within the European Union is proclaimed the intention to find a common understanding of quality and its ensuring, there is still no clear definition of the quality associated with the social system. In the article, there are defined steps that describe the direction of the Slovak Republic in solving this problem and barriers that limit this process. Slovakia is aware of the positive aspects of quality assurance of lifelong learning and therefore pays great attention to creation of detailed analysis of lifelong learning and its quality in the Slovak Republic. These analyses should clearly and distinctly point out the strengths and weaknesses resulting from the internal environment, as well as opportunities and threats that come from external environment. Proposed solution expects that quality management in informal education system will be provided by national authority. National authority will perform tasks like certification of educational institutions, accreditation of non-formal education programs in modular form, certification of trainers and consultants of non-formal education and thus will guarantee state control over the quality of lifelong education and lifelong guidance.

Keywords: Quality, Quality Assurance, Lifelong Learning.

1 INTRODUCTION

Within the European Union there have been a number of initiatives in education, including EQAVET (The European Quality Assurance in Vocational Education and Training), ENQA (The European Association for Quality Assurance in Higher Education), ENQA-VET, EQARF (The European Quality Assurance Reference Framework), EQAR (European Quality Assurance Register for Higher Education), QALLL (The Quality Assurance in Life Long Learning with a Focus on Vocational Education and Training and Adult Education), CQAF (The Common Quality Assurance Framework), EQF (The European Qualifications Framework), ECVET (The European Credit system for Vocational Education and Training), ECTS (The European Credit Transfer and Accumulation System) and various projects within Leonardo, Comenius and other programmes.

Junaskova [1] states, that the area of quality assurance in education requires syncretism, i.e. a need to integrate the views in this area. The key elements of any European and national activities in the area are:

- recognition of results of individual efforts;
- recognition of educational results as an integral part of national qualification (qualifications systems are not processed in the Slovak Republic) and
- coordination of individual projects focused on the quality of lifelong learning.

Across the EU it is not uniformly understood what lifelong learning (LLL) is. It seems that everyone is familiar with the definition but it remains underestimated especially in the areas of non-formal education and informal learning.

Similar inconsistencies and confusion exist in the understanding of quality LLL: whether it is quality management, quality assurance, quality control, quality assessment or quality improvement, or whether all of them and whether there are some other aspects. Contribution to the unification of the understanding of quality in education is only a recommendation of the European Parliament and the Council of June 18, 2009 establishing the European Quality Assurance Reference Framework for Vocational Education and Training no. 2009/C155/01. When trying to understand the LLL in the Slovak Republic there are supposed several false facts:

- the state must take on full responsibility for LLL,
- formal education itself can lead to obtaining different levels of education,
- work on standards of education is the only important step towards achieving high quality education,
- it is necessary to separate the process of accreditation and national qualifications systems.

[4]

2 THE ANALYSIS OF CURRENT STATE IN QUALITY ASSURANCE IN THE SLOVAK REPUBLIC

The status of quality assurance in the LLL in the Slovak Republic can be characterized as follows:

TABLE 1. The status of quality assurance in the lifelong learning in the Slovak Republic.

There is national legislation but ...	...is fragmented across sectors
There is a law on LLL in the Slovak Republic but...	...it does not deal with the LLL in a complex way
In Slovakia many resolutions have been signed but...	...work aimed at putting them into practice goes just slowly ahead or has not been started yet
Steps shall be taken in the field of quality assurance but...	...are not sufficient for some groups of learners
There is an attempt to introduce self-assessment for the LLL institutions in the Slovak Republic but ...	... this brings just more red tape
In the Slovak Republic there are rules for accreditation but...	...there are no qualification standards, but excessive bureaucracy, a too long approval process which discourages the candidates for accreditation

Source: A. Junaskova, "The European policy of quality in education" Proceedings of National Conference: Quality in Education, Žilina, Slovakia, 2011.

Steps of Slovakia that are not aimed on quality and that characterize the current situation are related to the link between research and development of LLL. We can describe them as follows:

- low awareness of all players in the field of LLL;
- low or zero fiscal policy;
- insufficient involvement of partners who are employers;
- reluctance of institutions providing formal education to perceive the education market as a "commercial" market;
- underestimation of non-formal and informal education leading even to legislative ignorance (traditionalism, i.e. it seems that the Slovak Republic is not interested in recognition of education; many strategy establishers state that "the LLL is not suitable for the business world").

Steps of Slovakia towards the quality which are also linked to research and development of LLL:

- to start the revision process of the Law no. 568/2009 on lifelong learning;
- the ongoing process of proposing the National System of Qualifications;
- handle the number of projects dealing with quality LLL;
- activities aimed at processing of external quality assessment of LLL institutions;
- self-assessment of LLL institutions (however, it has not been unified yet and remains fragmented);
- establishing the National Reference Center for the Area of LLL - NIOVE - National Institute of Vocational Education;
- establishing a working group to assure quality of the LLL which will work within the Ministry of Education, Science, Research and Sport of the Slovak Republic. [3]

Other challenges for quality assurance when linking research and lifelong education in Slovakia include in particular the effort to define objectives, indicators and quality standards of linking of research results and the LLL, to make clear what we want to achieve in the quality of research results and the LLL. It is also necessary to define mechanisms for ensuring the quality of the link between research results and the LLL to make clear how Slovakia intends to achieve quality. When defining partners in ensuring the quality of the link between research results and the LLL we find out for whom the quality assurance of the link is necessary. To meet the Deming PDCA cycle it is inevitable to ensure maintaining and improving of the quality of the link between research results and the LLL. This can be achieved by defining new and progressive objectives in providing a high quality of the link between research results and the LLL.

The benefits of quality assurance in the LLL can be defined as follows – mobility (work and educational markets), employment, attractiveness of vocational education and training, equality of opportunities, support for disadvantaged groups, response to sector requirements with regard to the lack of/surplus of certain qualifications and more flexible response to demographic changes in the country.

The education system and counselling have insufficiently reacted to the needs of the labour market in Slovakia. Typical is absence of open system of LLL for the labour market, insufficient ability of the formal education system to respond flexibly to the need of new skills by establishing new subjects and studies, mutual interrelatedness between formal and informal education system, no recognition of informal education for purposes of qualification acquirement, lack of state-guaranteed quality of informal education, absence of ongoing monitoring and surveying the educational needs in the country, absence of lifelong counselling for all phases of education and active life, absence of a sufficiently transparent and effective way of financing the formal and informal education and learning, insufficient development of key competences for LLL and persistence of gender stereotypes. [2]

TABLE 2. A brief SWOT analysis of the educational system.

Strengths	**Weaknesses**
• an organized **formal education system** • a rich offer and a relatively high interest in learning in **the informal education system** • **informal** learning is a natural way of acquiring knowledge and skills	• low flexibility of **the formal education system** • outstanding system elements in **informal** education: *1. quality assurance; 2. financing; 3. recognition of learning outcomes* • a high level of disorganization in the **informal** learning
Opportunities	**Threats**
• equality of the informal education system and the **formal one** • use of the outcomes of the national project conducted by Academia Istropolitana to promote **informal** education: *1. certification of educational institutions, certification of lecturers, accreditation of educational programs; 2. national qualifications authority;* • a shift in the assessment paradigm applied for learning outcomes. It has been based on measurement of inputs and the shift is expected rather towards measurement of outcomes (results of the so-called education. *"Learning outcome principle"*), which is applicable also for recognition of results in informal learning	• resistance of employers and of the **formal system** to recognize education obtained in the informal system • disinterest of the decisive sphere to create conditions for implementation of innovative features into the **informal** system and resistance of the formal system to accept these innovative elements • devaluation of formal and informal education

Source: J. Mikolaj, “Strategy of lifelong learning and lifelong guidance” [draft], Bratislava, 2010.

Description of the open system of LLL in Slovakia for the needs of the labour market is provided in conceptions for individual subsystems of LLL, covering all components of education - formal education, informal education as well as informal learning. These conceptions, mutually interlinked, were developed by Academia Istropolitana, the educational institution of the Ministry of Education, within the national ESF project “Establishing, development and implementation of an open system of LLL in the Slovak Republic for the needs of labour market.” Expertise within the project started in 2004 and was completed in March 2007.

Elements of the open system of lifelong education in the Slovak Republic:

- System monitoring and survey of educational needs aimed at prognosis and the information system on the LLL.
- The high quality system of LLL with emphasis on the quality of informal education and informal learning.
- Recognition of results of informal education and informal learning for obtaining qualification – permeability.
- Support tools for lifelong learning financing.

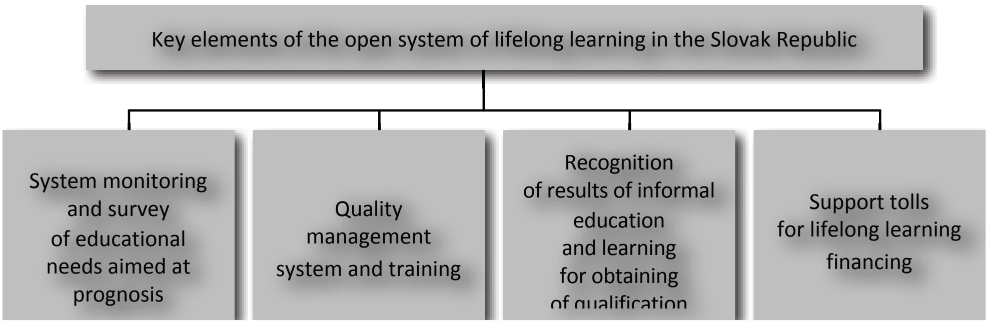

FIGURE 1. *Key elements of the open system of lifelong learning.*

Quality of the vocational education is partially guaranteed by the state through the evaluation by the Accreditation Commission of the Ministry of Education, Science, Research and Sport of the Slovak Republic (small Accreditation Commission). The adoption of the amendment Act no. 567/2001 386/1997 statute on further education in 2001 strengthened the powers of this commission. Currently, the following continuing education activities must be accredited:

- educational activities targeted at public officials;
- educational activities funded from the state budget.

In order to obtain accreditation for an educational institution a concept of educational activities must be submitted (a project and pedagogical documentation, documentation of lecturers and material-technical equipment). Each project is evaluated by an expert group which is proposed by the Ministry of Education, Science, Research and Sport of the Slovak Republic. Accreditation of educational activity shall be valid for five years, but during that period there is no quality supervision of the accredited continuing education activities. Educational activities which are not designed for public officials and are not financed from the state budget may not be accredited. Despite this fact, many training providers apply for accreditation on their own initiative. For many institutions accreditation is an effective marketing tool: accredited activities are a sign of credibility of educational institutions in the eyes of the public. A specific rule applies to the accreditation activities of continuing vocational training for certain professions (for example in the health sector, education and public administration). Ensuring the quality of this type of vocational education is normally in competence of ministries under which the profession in question falls (such as security and quality evaluation of educational activities of health workers is under the auspices of the Ministry of Health of the Slovak Republic).

Business education is another type of training which is subjected to monitoring and thorough evaluation (especially in large companies with foreign participation). The results of such evaluations are generally not available to public. Monitoring and evaluation are conducted also within trainings for unemployed people by providing employment services, social affairs and family and are publicly funded. Evaluation of the effectiveness of this type of training is based on number of the unemployed who found a job after training accomplishment. Some experts have suggested that this method of evaluation is not indicative of the true effectiveness of further training for the unemployed. It is assumed that many unemployed who have been involved in the education and later found a job would find the job also without participation in the educational activity. The current method of monitoring and subsequent evaluation of this ignores the fact. After having summed all the activities of vocational education and training which are subject to assessment, it is obvious that most of further education programmes financed by the participants themselves (for example very popular foreign language and IT courses) are not subjected to any systematic quality assurance. We can only assume that low-quality providers of continual education services gradually eliminate the competitive environment in this area. The issue of quality of the vocational education in the Slovak Republic is important: Act no. 455/1991 Coll. on Trades (Trades Act) as amended defines providing further education as a freelance business, which means that people who are interested in the business of providing some continuing education do not have to meet any specific criteria related to professional qualifications or experience. The Association of Adult Education Institutions (AAEI) has sought to improve the mechanisms for ensuring quality of trainings and in collaboration with two faculties has established a system of certification of teachers active in the field of further education. This system cannot be regarded as an official national system of certification of lecturers as the AAEI is not a national certification or accreditation authority.

In Slovakia there the innovative efforts are reflected in projects focused on the issue. We present examples of projects in progress and of the ones completed in the years 2010 – 2011:

- Vocational Education and Training in Europe (EUROVET) – 2011 - 2013;
- Increasing Quality of Future Teachers within the Educational and Certification System – 2011 - 2013,
- Financing Training in Europe – 2011 - 2012;
- Activities of the European Qualification Framework National Coordination Points with a view to implement the EQF at national level – 2011 - 2012;
- European Life Long Policy Network (ELLPN) – 2011 - 2012;
- Programmed for the International Assessment of Adult Competencies (PIAAC) – 2011 - 2013;
- Continuous Cross Border Improvement of National Lifelong Learning Strategies (CCBI-NLLS) – 2010 - 2011.

3 THE DRAFT OF QUALITY ASSURANCE WITHIN LIFELONG LEARNING CONTAINED IN THE STRATEGIC DOCUMENTS

Mikolaj (in the position of the Minister of Education at that time) states that the quality management system of the formal education is directly embedded in the legislation related to the formal education at all levels. [2]

Quality management in the informal educational system will be provided by a national authority that was established and is entitled for educational activities under the auspices of the ministry. The National Authority referring to the future legislative intent of the law on lifelong learning shall perform the tasks qualifying to certify educational institutions, to accredit non-formal educational programmes in modular form to allocation of credits to individual modules, to certify trainers and managers of non-formal education and consultants, and thus to guarantee state control over the quality of lifelong learning and lifelong counselling.

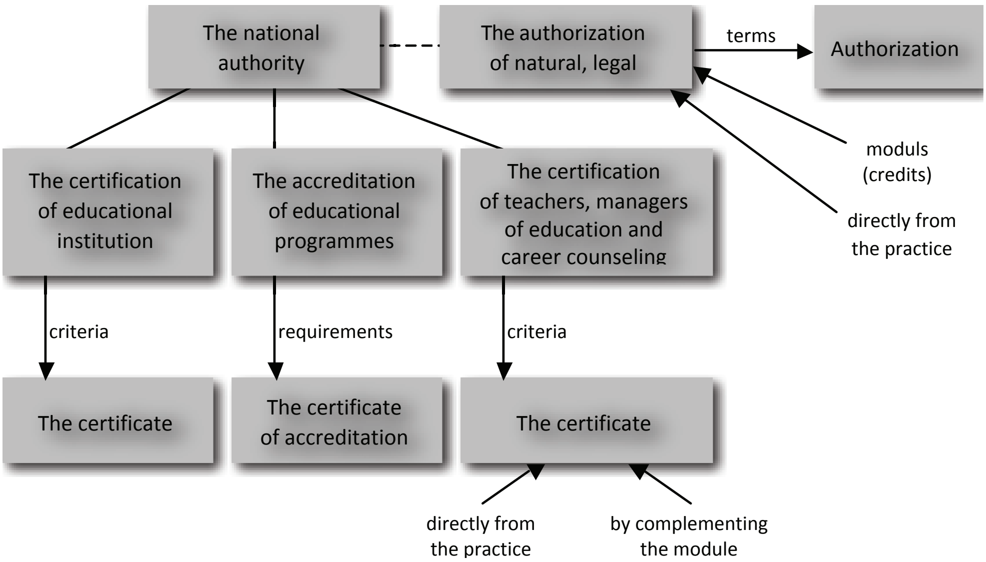

FIGURE 2. *Proposal of quSystem of quality control and system of results recognition.*

4 CONCLUSION

The quality of the lifelong learning in Slovakia has not been reflected yet in any strategic document, there is only a proposal. The law No. 568/2009 on Lifelong Learning does not provide solution to the issue of lifelong learning quality in a complex way and does not contain any direct reference to the links of research results and the lifelong learning. Institutions of lifelong learning approach the ensuring of quality in different ways (ISO standards, CAF, etc.). On the whole, perception and definition of the concept of quality in the lifelong learning in Slovakia is heterogeneous and therefore there is a need to unify the approaches to the issue at the strategic as well as tactical level.

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Creative Economy – National Economic and regional conditions and incentives (Kreatívna ekonomika – národohospodárske a regionálne podmienky a stimuly); APVV-0101-10

Implementation of complex research activities in selected field of services and cooperation with partners - Phase 2; IV

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154 OPEN-SOURCE AS ENABLER OF ENTREPRENEURSHIP AMBITIONS AMONG ENGINEERING STUDENTS – A STUDY INVOLVING 20 FINNISH STARTUPS

Jose Teixeira[1] & Joni Salminen[2]

1 University of Turku, Finland, Jose.Teixeira@utu.fi
2 University of Turku, Finland, Joni.Salminen@utu.fi

ABSTRACT

This exploratory study assess the role of open-source software on the entrepreneurship initiatives of engineering students. Taking a case-study approach, the authors interviewed 20 start-up organizations present at a demo-area on one of the biggest entrepreneurship events in Europe. At a later stage, several key technological entrepreneurs were identified and their academic background was subjected to analysis using the Linked-in social network. Findings suggest that open-source software plays an important role in everyday life of the studied start-up organizations. Moreover, the authors suggest that educators, seeking an increase of entrepreneurship initiatives from their students, should increase the exposition of their students to open-source technologies and promote the creation of independent and multi-disciplinary entrepreneurship societies.

Keywords: Open-source, Entrepreneurship, Finnish startups

1 INTRODUCTION

1.1 Entrepreneurship, society and education

Entrepreneurship, as the act of individuals becoming entrepreneurs, is widely-accepted as a good and desirable phenomenon in our society. The ones undertaking innovations, finance and business acumen in an effort to transform ideas into new businesses, commonly referred as start-ups, are creating an valuable economic and social god. However, as claimed by Shane (2003) entrepreneurship is rather poorly explained by academics, limiting the governance, stimulation and exploitation of entrepreneurship opportunities

Much descriptive and explanatory research already exists on the entrepreneurial process. Wide accepted multidisciplinary research exists on the effects of individual and cultural attributes on the entrepreneurship initiatives. Recent advances in organizational and innovation studies also pointed their lenses at the entrepreneurship phenomenon. However, when seeing entrepreneurship from universities governance perspective, the existing relevant theoretical body is quite limited. Some research reveals the importance of promoting entrepreneurship in higher education, but few models and guidelines exists for guiding the higher-education leadership.

“Much of our American progress has been the product of the individual who had an idea; pursued it; fashioned it; tenaciously clung to it against all odds; and then produced it, sold it, and profited from it” - Hubert H. Humphrey (1966)

1.2 On entrepreneurship and engineering education

Some published academic research advocates the stimulation of the entrepreneurship phenomenon within engineering education. The researchers Meltovaara and Lindström (2011) describe their approach aimed at fulfilling the prerequisites of entrepreneurship by introducing an new syllabus for students of automotive engineering and logistics. Kairisto-Mertanen and Mertanen (2008), pursued the same goals by driving students to participate in different entrepreneurial learning environments; both business and engineering students established and run co-operatives and carry out different project in collaboration with local players.

1.3 On open-source and entrepreneurship

Several studies link the open-source and entrepreneurship phenomena. For instance, Zutshi (2006) provides an detailed explanation on how e-entreprenetures make use of open-source. Advocating the open-source phenomena, Perens (2005) claims that using open-source cut way down on start-ups software costs. Expanding and customizing open-source technologies is by far easier and the economic costs of failing are lower than in big coorporate initatives (Perens 2005).

On other hand, some studies are quite critical on entrepreneurs embracing the open-source phenomena. Bärwolff (2006) claims that venture capitalists entering in the open source arena are taking on some financial risks. Stam and Elfring (2008) reports that open-source start-ups firms experienced legitimacy problems, as reflected by the scanty public knowledge regarding open source software and the lack of support from organizations with vested interests in the proprietary software market

1.4 Bridging open-source, entrepreneurship and engineering education

The authors did not find relevant literature literature bridging the open-source phenomenon with the topics of entrepreneurship in engineering education, raising the following research questions: First, ”Does open-source software play any role in the entrepreneurship ambitions of engineering students?” ; and if consequently ”How higher-education leaders can better stimulate students-entrepreneurship?”. Without an answer from the academic literature, the authors were driven in an empirical quest trying to get the answers by methodologically observing, studying and interacting with entrepreneurs on the terrain.

For contextualizing the research questions with empirical cases, we can provide the examples of bambuser.com and walkbase.com. Two recent technological start-ups, both employing and innovating, that already secured an considerable amount of seed funding. Both ventures, providing software products and services being used by thousands of users worldwide over the Internet, started as student projects in Åbo Academy in Finland. We rise then the discussion

:"Did open-source play any role in the entrepreneurship ambitions of their founders?", "How can the University stimulate more cases of student-run start-ups?"

Rather, than limiting our research to the previous mentioned two cases, we addressed the research questions by pointing our lenses to 20 other start-ups in an early stage that are currently operating in the Nordic region. The following chapter describes the methodological approach followed and we later provide how the captured research data was analysed. In the last section, we present our contributions to the body of theoretical knowledge in engineering education and attached governance implications. We close this paper by discussing and warning about possible generalizations from a study conducted solely in Northern-Europe geographies.

2 METHODOLOGY

In this regards, we have adopted a theory building approach as described in the taxonomy of research methods from Järvinen (2004). By analysing the role of the open-source software phenomena in the reality of the Finnish entrepreneurial start-ups, our empirical study lead to dissencus from the current body of theoretical knowledge on entrepreneurship and engineering education. This study is a qualitative and exploratory in the moulds of Eisenhardt (1989), Stebbins (2001) and Yin (2002) for social science research. Data was collected from semi-structured interviews performed by both authors at Slush 2011, an start-up conference attracting start-ups and investors in Europe's Nordic region, during the the second and third of November 2012.

Interviews were performed by informal and flexible manners with interviewers and interviewees following the a priori questionnaire provided in the apendix, but also further exploring other issues on the interest of both parts. At different timings, one of the authors inquired about the venture goals, business model, funding rising and product development efforts; other author, more interested in the open-source phenomena, asked afterwards both about the use and offer of open-source technological components by the venture organizations. Interviews were conducted in the Finnish and English language and paper notes were taken with pencil in two discrete paper notebooks.

From 50 start-ups at demo stands present at Slush 2011, we randomly selected and interviewed 20 start-ups. All start-ups been extremely collaborative and did not had issues in collaborating with the authors that always introduced themselves as researchers from Turku School of Economics. Two interviewees, where not able to answer in-depth technical questions out of their startup competences, but as agreed, they provided the missing answers aftewards by email. All answers and notes taken been typed, organized and categorised in digital formats less that 24 hours after being collected.

The use of interviews in exploratory and qualitative research has been accepted by the entrepreneurship academic community. For instance (Murray 1996) used case study methodology to identify the roles of venture capital investments in newly established technological firms, Zutishi et al. (2006) interviewed two entrepreneurial organizations to assess the implication of the new open-source software distribution model for entrepreneurs on e-business.

The Linked-in social network was used afterwards to screen the academic background of all 21 intervieweed entrepreneurs present at Slush 2011. Thanks to the social network, we were able to identify for every studied organization their founders/co-founders and respective educational background. Surprised with an considerable number of entrepreneurs with foreign origin operating in Finland, we decided to collect additional information on their national background and holed foreign degrees.

3 ANALYSIS OF COLLECTED DATA

Demonstrating rigor through a careful and comprehensive articulation of data analysis is a critical issue in improving the robustness of qualitative research. The qualitative inquiry as presented by (Eisenhardt 1989) and (Miles & Huberman 1994) guided the data categorization and analysis within this research. Popular and wide available software tools facilitated the interviewees data categorization: a text editor, a spreadsheet processor and some mindmap software were used.

Different theories and empirical perspectives were applied on the collected data. The authors searched for patterns reflecting who are the entrepreneurs, their academic background, their ambitions and on how are they conducing their business ventures. The authors, constrained by their educational background, employed mostly the marketing, entrepreneurship, computer science and information systems perspectives to reason from data. However the collected data might have value for other areas of expertise.

Complementary data, regarding the entrepreneurs curriculum in general and their academic background in particular, was collected a posteriori from the Linked-in social network and treated as Silverman (2009) natural occurring research data. A set of had-hoc hypothesis, related with entrepreneurs exposition with the open-source phenomenon during their graduate studies, emerged during the analysis of the collected data and the authors were required to perform a syllabus analysis of several graduate courses among some Nordic higher-education institutions . This last analysis was based on public-available textual information such as study guides and virtual learning environments. Textual information was collected in Finnish, Swedish and English languages and allowed us to test most of our analysis driven had-hoc hypothesis.

4 IMPLICATIONS AND DISCUSSION

Open-source seams to play an important role in everyday life of start-up organizations, especially among organizations founded by entrepreneurs with high-technological academic background. In a universe of 20 start-ups: 20 were using open-source software development tools; 19 were embedding open-source technological components in their products and 14 were working up-stream, contributing back to the open-source community. Moreover, three entrepreneurs considered their developments as open-source products, and a forth one was planning to open-source their product blueprints; all this reveals a considerable correlation between open-source phenomena and the Finnish entrepreneurship initiatives.

By investigating entrepreneurs academic background on Linked-in, it is important to refer that, a considerable amount of studied start-ups, manifested high diversity on the academic and cultural backgrounds of their founders. Many start-ups were initiated by teams of entrepreneurs from completely difference academic backgrounds i.e. (a chemist, a computer scientist and a ethnologist) and different cultural background i.e (entrepreneurs with Finnish, Indian and Turkish origins collaborating in the English language).

The same investigation based on the entrepreneurs academic background, suggests that a high number of the identified entrepreneurs followed the same higher-education paths. Two Finnish universities, well-known in the national panorama for promoting Linux and open-source technologies in their study programs, educated together more than half of the investigated entrepreneurs. This could suggest an important and novel correlation between the promotion of open-source software at universities and the entrepreneurship ambitions and capabilities of their students. The same two universities also host students entrepreneurship societies empirically well-known for intensively promoting early entrepreneurial thinking among their students.

The authors propose then two managerial implications for universities wishing to promote entrepreneurship among their students: First, increase students experiences with open-source software and, secondly, promote student's entrepreneurship societies willing to grab together students from diverse academic and cultural backgrounds. Everyone willing and interested in start-ups could then practice, at side of their studies, many aspects of corporate-life such as pitching, product-development, sales, team-work, coaching, marketing, etc.

By including open-source software in the syllabus, over promoting the teaching of high-branded technologies from Oracle, Sap, Cisco, IBM, Microsoft to engineering students, we allow students to play with more open and transparent technologies. Those last ones, by promoting standards; releasing their blueprints; and voiding lock-in mechanisms; are more likely to be deeply studied and integrated by possible student-entrepreneurs. Many of the products showed by entrepreneurs at Slush 2011, were not a reality without the low entrance costs, interoperability and rapid prototyping characteristics of open-source software .

Moreover, for developing countries it does not interest to graduate hundreds of consultants both on Oracle, Sap, Cisco, IBM, Microsoft corporate manners and technologies. Once students graduate, they are going to compete in a price and language basis with thousands of graduates from the developing world that dominate the current outsourcing, in-shoring and off-shoring tendencies of the industry. The authors suggest that, many open-source entrepreneurs would became consultants on their own public-domain solutions addressing the more specific needs of the local market. Those ones, are in better position to make the difference by their knowledge and expertise on a specific product/problem rather than on the consultancy hourly rate for projects involving high-branded general-purpose product/solution.

Finally, the authors would like to encourage the creation of independent student-run entrepreneurship societies were student-entrepreneurs and students interested in start-ups could find support for realizing their entrepreneurship projects. In Finland, Boost Turku, Aalto Entrepreneurship Society and Hanken Entrepreneurship Society are examples of entrepreneurial community of students, alumni and researchers developing entrepreneurship skills and awareness . Those societies are operating in English and encourage the participation of everyone independently of their studies background or nationality. Both by the number of students involved in events organized by the mentioned bodies and by the number of student running start-ups that operate for more than one year, those societies are playing a good role in creating jobs for skilled students in a society where graduates unemployment rises year after year.

5 CONCLUSION

Our core findings suggest that open-source software plays an important role in everyday life of the studied start-up organizations. Moreover the authors recommend, to educators seeking an increase of entrepreneurship initiatives among engineering students, both to increase the exposition of their students to open-source technologies and to promote the creation of independent and multi-disciplinary entrepreneurship societies.

The authors must warn on possible generalizations from this qualitative study conducted solely in Northern-Europe geographies that covers solely a sample of start-ups dedicating their efforts to the creation and commercialization of high-technological software products and Internet services. Any generalization reasoning should be mitigated carefully.

Besides complementing existing literature on entrepreneurship and engineering education with a novel study on the open-source software role within student's entrepreneurship, this research provides new variables to a wide stream of research on "Who is the entrepreneur" and "How entrepreneurs do it by taking opportunities into business ventures?" currently fomenting a vivid debate within entrepreneurship research.

We conclude this paper by challenging quantitative researchers on entrepreneurship and education, to make more rigours assessments on this research both by testing our theoretical propositions and by considering of open-source education as a variable capable of affecting the technological entrepreneurship process.

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155 PROMOTING PEDAGOGICAL SKILLS AND A MORE HOLISTIC VIEW OF ENERGY ENGINEERING EDUCATION

Helena Mälkki[1] & Jukka V. Paatero[2]

1 Aalto University, Espoo, Finland, helena.malkki@aalto.fi
2 Aalto University, Espoo, Finland, jukka.paatero@aalto.fi

ABSTRACT

High-level university education is typically identified with broad overall expertise of lecturers and use of modern pedagogical methods and skills. This was also reflected in the Aalto University Teaching and Evaluation report published in 2011, which identified a more holistic view in teaching energy engineering and supplementary pedagogical education as a required development. The aim of this paper is to respond to these needs, and to explore educational models and approaches that could improve the learning outcomes and the quality of teaching.

Keywords: Energy, Engineering education, Curriculum, Professional skills, Sustainability

1 INTRODUCTION

Long-term sustainability or lack of it has received increased attention in modern society. Sustainability is typically divided into environmental, economic and social dimensions [1]. The various involved actors form a complex chain of interactions in the society and their degree of sustainability defines the overall sustainability of society. On the other hand, policies, laws and standards guide the decision makers in industry and society to choose the most feasible technologies and systems. As this working environment is complex and multidisciplinary, the cooperation between different disciplines is required. However, this is often difficult and lacks practices like the common language to discuss the problems. That is why new skills and knowledge are necessary to the decision makers, engineers, and other professionals in order to increase their ability to effectively address sustainability issues and to understand their holistic consequences to the nature and all the human beings and species living on Earth [2] [3].

Energy is a central element in all modern activities and it is important to understand its role in society. The society calls after new kind of engineers to be able to design sustainable solutions taking into account the best energy alternatives. These new skills need to be taught in University curriculums. They should provide the students with the new competences especially in critical thinking, systemic thinking, transdisciplinary cooperation and value consciousness. Moreover, the universities have the responsibility to educate graduates with a moral vision in addition to their necessary knowledge [4].

Energy engineering education should improve the perspectives of students on sustainable energy and general “energy system literacy.” An energy engineer requires analytical methods and tools to implement the concepts and best design practices into sustainable energy systems. The life cycle based approaches incorporated in energy engineering education can provide an ideal skill set for tackling a wide range of energy problems.

Including sustainability into university strategy and the commitment of management bodies on sustainability issues support the integration of sustainability skills into teaching. Sustainable use of energy, natural resources and human living environment are key focus areas set out in the strategy of Aalto University, for example [5]. However, currently the Aalto University energy engineering curriculum is lacking general sustainability studies that would provide the students with the corresponding professional skills they need. This paper focuses mainly on designing a holistic view into the teaching of the Urban Energy Systems and Energy Economics (UESEE) teaching module. The module will be upgraded with such teaching and learning practises that the students will get a broader and more holistic view on the broad scope of energy issues discussed in the curriculum. This type of upgrades was recommended to other parts of the energy engineering curriculum as well [6].

2 BACKGROUND

In case of environmental sustainability, the need for integration of environmental awareness into education and research started forty years ago from the publication of The Limits to Growth [7]. It presented the predictions of demand for finite raw materials and energy resources. As these predictions are now more relevant than ever, universities around the World have an opportunity to become key leaders in the movement to prevent the prevailing global ecological collapse. To address this, Moore has collected recommendations from interview transcripts and workshop to help universities in a transformation towards a long-term vision of sustainability [8].

Engineering plays a critical role in developing technical and technological solutions to problems. However, sustainability requires a systemic perspective, which encompasses the complex interdependence of social, cultural, political, and economic activities and the biosphere. The United Nations Decade of Education for Sustainable Development (UN DESD) [9] has directed attention to the integration of sustainable development (SD) in all educational settings [10]. On the other hand, teaching should be based on research according to the university strategies. Thus, there is an overall need to rethink and restructure the engineering education.

Energy efficiency is one of the most cost effective and sustainable ways to enhance security of energy supply, and to reduce the emission of greenhouse gases and other pollutants. The greatest energy saving potential lies in the buildings, while the transport has the second largest potential. The EU is committed to reducing greenhouse gas emissions to 80-95% below the 1990 levels by 2050 [11]. This is a challenging task and needs systemic thinking, transdisciplinary cooperation and value consciousness. The Commission analysed the implications of this in its “Roadmap for moving to a competitive low-carbon economy in 2050” and they imply major changes in, for example, carbon prices, technology and networks [11]. The roadmap highlights also that renewable energy will play a prominent role in a sustainable and secure energy system. As one of the front-line actors Finland has employed from 1990 a voluntary agreement scheme to promote energy efficiency and it will play a key role both in Finland’s national implementation of the Energy Services Directive, and in efforts to reach the national energy savings target [12]. In all

EU the energy efficiency will also be encouraged by the Emissions Trading Scheme [13] and the new Industrial Emissions Directive [14].

In order to achieve good results in teaching SD, the whole teaching process should follow the principles of SD. SD has many definitions and one of the most frequently quoted definitions is from the Brundtland Report [15]. The three dimensions of SD (economic, ecological and social) form a challenging combination in education. That is why the interdisciplinary co-operation is needed to refocus sustainability in education [16]. For example, a multidisciplinary group of teachers could plan in cooperation with the other teachers how they could take all three sustainability aspects into the context of energy curriculum and courses.

Lukman et al [17] have set a model to rank universities using research, educational and environmental indicators and they have presented activities which measure environmental dimensions of university. These activities involve four different categories: 1) voluntary agreements or commitments, 2) sustainability courses and sustainability programmes, 3) sustainability vision and mission, and 4) sustainability office, manager, council or consultant. This environmental ranking system does not reveal, however, the fundamental programmes where sustainability skills are needed after graduation. Aalto University provides programmes and courses with sustainability and environmental studies, but larger cooperation is still under a planning phase between different programmes and different schools. That is why individual teaching developments are needed to foster the needed new skills in a quicker time scale than the official reform would enable. This is also the case with much of the Aalto University energy engineering curriculum.

3 TEACHING APPROACHES AND METHODOLOGIES

Sustainability is a multidisciplinary issue and demands a specific kind of learning. Therefore learning sustainability should include multiple teaching methodologies that provide a range of different skills and broadens the perspectives of students` thinking. According to Segala's et al [4] there is a direct relationship between the learning of a transdisciplinary perspective and system thinking. They highlight also that SD courses at technological universities should focus their content on the social and institutional aspects of SD. Engineers are traditionally taught "hard sciences", but nowadays the working life competencies challenge more often the "soft sciences". These soft skills are achieved with the constructive and community-oriented pedagogical approaches.

A teacher has to consider various teaching methods when planning and developing study modules and individual courses. The teaching methods should be selected according to the learning goals of the curriculum and they should enable learning by supporting the prerequisites for studying. The curriculum presents the learning outcomes for the students while the teachers have to choose the suitable educational methods to achieve these goals. Teaching in itself does not mean that the students will learn. The teacher should take the taught subject, the actors involved in the learning process, the individual nature of learning, and cultural differences into consideration. The students need also to be active by themselves in learning. [18]

The article of Ceulemans et al [19] discusses horizontal and vertical integration of SD in curricula. In the horizontal integration, SD is interwoven within different courses of the curriculum, while the vertical integration can be understood as the organization of separate SD courses within the curriculum. However, they all focus on the necessity of a systemic, holistic, and interdisciplinary approach towards SD.

The teaching portfolio addressed in this paper is the one contained in the UESEE teaching module (see Table 1) that is offered as a minor to students throughout the Aalto University. As such, the module provides the students a basic understanding about the energy technologies applied in the urban environment and urban energy infrastructure, urban planning and its connections to urban energy planning, energy investments, energy markets, district heating engineering, and energy system models optimization at different levels. As the scope of the studies is very broad, the four courses provided in the module relate to each other mainly in a horizontal manner, not building on the knowledge of each other. In addition, the students can freely choose the order they wish to take the courses. The only exception is the course "Models and Optimization of Energy Systems," where the knowledge from the course "Energy Markets" is required. As a result, whatever methods applied in the teaching, there is only a very limited possibility to build on the knowledge and experience of students from the other courses within the module.

TABLE 1. Urban Energy Systems and Energy Economics (UESEE) teaching module.

Minor in Energy Systems for Communities and Energy Economics, Module I (20 cr)	ECTS Course Points
Models and Optimization of Energy Systems	5
District Heating Engineering	5
Energy Markets	5
Energy Systems for Communities	5

There is a relatively broad consensus that teaching methods where students are activated and involved as participants provide the best learning results [20, 21]. To ease the identification of the nature of particular teaching approach or course, Elsen [20], based on the work of Healey [21], has developed a four-field presentation concerning how the teaching is oriented. It can be used to divide teaching into student-as-participant or student-as-audience type on one axis and into research content or research process and problems emphasizing teaching one the other axis.

Increased use of student-activating teaching methods is also a welcomed change in the courses of the UESEE teaching module. The authors have applied the list of student-activating teaching methods provided by Ceulemans et al [19] and selected several of them to be implemented in the UESEE curriculum. In Figure 1 these methods together with classical lecturing have been placed into the four-field by Elsen [20]. It can now be seen, that most of the selected student-activating teaching methods fall into the upper right corner of the four-field. It thus seems that student-activating teaching also often results in more research process and research problems emphasizing teaching.

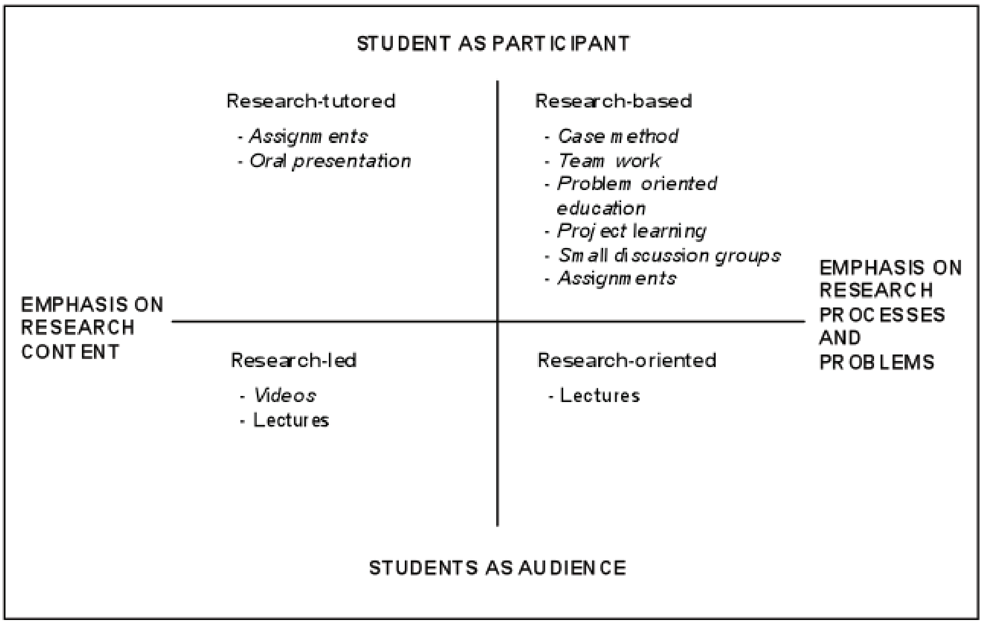

FIGURE 1. *Selected student-activating teaching methods (Ceulemans et al [19]) and classical lectures in the four-field curriculum design division based on Healey [21] and the discussion by Elsen [20].*

Due to the mainly horizontal alignment of the courses and that the module is offered as a minor to all students in the Aalto University, the student-activating methods applied in the teaching need to be based on the assumption that students have no prior experience of the applied methods. Additionally, there is only limited possibility to build that knowledge within the module. The teaching will therefore rely mainly on basic ways of using the student activating methods. If very advanced group work methods will be applied, for example, a detailed guidance and support system needs to be designed for the students.

Many of the student-activating teaching methods have the secondary benefit of teaching the students valuable skills that they need in working-life. Thus the selected student-activating methods will be chosen and applied in the courses not only in a manner that they form a balanced overall coverage and provide students introduction to this method but that they also give the students a balanced set of learning results in the selected working-life skills.

4 ANALYSIS AND EXPECTED RESULTS

The effective changes in the pedagogical approaches are based on the alignment of the courses with the modules of the whole study programme. This teaching development work is ongoing in the energy study programme at the Aalto University and all the individual energy courses have earlier been evaluated [6]. Now the existing teaching contents will be analyzed again using the core curriculum analysis [22]. This in-depth analysis is done for both the scientific and professional learning goals. Some preliminary indications of the results have already been obtained, while the full results will be published at a later time. With the help of the student-activating methods, these learning goals are then updated to provide a balanced portfolio of key scientific and professional skills needed for an urban energy system and energy economics expert.

The preliminary indications from the results of the core curriculum analysis of the existing course are suggesting that major lacks are present in the current learning goals. Particularly, the systemic approach to understanding of energy systems seems to be limited to engineering-only view, while also the sustainability aspects of energy systems have only limited weight at the module-level curriculum. In addition, the professional skills seem to have very limited emphasis in the module-level curriculum.

These preliminary indications suggest that the detailed analysis most likely reveals a need for major revival of the teaching concerning systems thinking, sustainability, and professional skills in general. The authors expect that adding problem based learning teaching about sustainability topics that takes place in group work environment will partially address these lacks. In addition, group discussions and debates between students groups concerning sustainability issues is likely going to give a valuable contribution to the overall package. However, details about these remedies to address the lacks in the teaching portfolio are going to be addressed in a later work.

5 CONCLUSIONS AND DISCUSSIONS

Advancement of interdisciplinary understanding and proactive teaching and learning processes has become increasingly important in tackling the complex landscape of sustainability. It is important to understand the role of energy and engineering education in society. The role of universities is to educate professionals for all sectors of society. Teachers of technical universities educate energy engineers. The energy engineers need the systemic approach to understanding of sustainable energy systems. Society needs a culture to support responsible decision-making and decision-makers need the appropriate education to achieve the professional skills needed in tackling the sustainability challenges. The active teaching methods bring more concrete learning outcomes to students and increase collaboration between students and enterprises in energy problems. The student-centered learning activities emphasize experimental and communal aspects of learning and the importance of explicating thoughts and ideas through brainstorming, assessment, and reflection in energy issues. An energy engineer requires also analytical methods and tools to implement the concepts of the sustainable energy systems. The life cycle based approaches incorporated in teaching energy engineering would provide an ideal skill set for tackling this wide range of energy problems.

6 ACKNOWLEDGEMENTS

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156 FACILITATING INNOVATION COMPETENCES: INTEGRATING BUSINESS AND ENGINEERING

Kristiina Meltovaara[1] & Juha Leimu[2]

1 Turku University of Applied Science, Turku, Finland, kristiina.meltovaara@turkuamk.fi
2 Turku University of Applied Science, Turku, Finland, juha.leimu@turkuamk.fi

ABSTRACT

Turku University of Applied Science (TUAS) applies innovation pedagogy, which refers to an approach to learning and teaching that emphasises working life skills. It moves from the tradition theoretical learning to the application of learned skill to practical development challenges providing students with a variety of skills in addition to theoretical knowledge.

In Finland industry feedback with reference to required graduate skills has been twofold. On one hand a solid technical knowledge basis is required of students and on the other the technological knowhow is secondary to project management and networking skills. By implementing innovation pedagogy, where new teaching approaches are combined with teaching the theoretical know how, both these industry requirements are addressed. In conclusion, by teaching the theoretical subjects throughout the entire degree programme and simultaneously applying innovative teaching methods, students are better equipped with the requirements of their future employees furthermore each student's individual strengths and knowledge profile are emphasised. Employees are provided with pool of graduates with the technical knowhow, project and social skills required in the changing business environment.

Keywords: innovation pedagogy, working life skills, innovative teaching methods.

1 INTRODUCTION

The tradition of Finish engineering education has strongly concentrated to the basic skills of engineering. [1] The industry has traditionally received young engineers with high standard basic skills. The working life routines were learned during the practice periods, while the project work skills and cooperation with foreign colleagues and customers were learned in practice throughout the first place of employment. In Finland a change in the education system has faced numerous changes over the past few decades, as a result of which the amount of students strongly increased without increasing the number of teaching staff in proportion to the increase in student numbers. This in turn reduced the amount of time spent learning the basic engineering skills. The need for social group working skills and project management and working in international environment were recognized at the same time [2]. As a response to the new demands degree credits were used to teach these skills using traditional class room lecturing methods. This together with the reduced working hours per credit has affected the learning outcome and has simultaneously been criticised by industry.

In the near future no immediate increase in the teaching resources can be envisaged. The need for a change in engineering education has been recognised worldwide (www.CDIO.org and engineerofthefuture.illinois.edu) TUAS has partaken in both the CDIO framework and the Engineering of the Future summit. The CDIO initiative is a framework providing students with an education emphasising the engineering fundamentals of Conceiving, Designing, Implementing and Operating real-world systems and products. The Engineering of the Future summit focuses on the transformation of the engineering education by specifically emphasising student engagement in and for the transformation. Both the framework as well as the student involvement method, have been applied side by side by the industrial management engineering (IME) study line at TUAS to further enhance and develop a new approach to teaching whereby graduates possess both the basic engineering skills as well as the interpersonal and teamwork skills.

2 AN ALTERNATIVE APPROACH

Most of the engineering work in business life is done in multi professional groups, as projects, including at least oral and written reporting in English. The tradition of education separates these elements. Furthermore, the basic engineering skills are recognized as difficult subjects by and for students and at the same time essential for most graduated engineers during their first years in working life.

Teaching communication skills, project management, reporting in foreign languages without connection to the professional context has induced frustration in all participating actors. The efficiency in the use of time resources could be increased as well as the learning results. A part of the innovation pedagogic process as seen by IME, is that these elements which belong together are together and are not separated as highlighted in the following. Thus the teaching methods should be developed so that the main concern is in learning the difficult basic engineering skills while simultaneously applying and practicing the needed working life skills. At the Turku University of Applied Science (TUAS) innovation pedagogy has been applied – a model for a developing a new approach to learning in higher education. [2] Innovation pedagogy is a learning approach, which defines in a new way how knowledge is assimilated, produced and used in a manner that enhances learning and can create innovations. It combines learning with R&D activities and working life in a cross-disciplinary and social learning environment. The new way of thinking, which is in line with innovation pedagogy, means turning knowing to understanding and further to developing understanding to the ability to apply the learned knowledge.

This innovation pedagogy process has successfully been applied by IME at the TUAS by integrating courses with each other e.g. the integration of 5 credits of machine technology with 5 credits of English language. The class is divided to groups of 5 students. Each group selects a technical system which is analysed. The credits and support for searching information, undertaking measurements and observations, calculations and analysing the system is obtained from the course of machine technology. All technical work in industry is reported in writing or orally. In this case the students are able to write a thick report and rewrite it several times under the guidance of the English language teacher and the credits for the reporting work are given from the language course. The feedback of the texts is given in the working groups so that all the students writing the same report hear each other's feedback. An oral presentation is given at the end of the course and also the supporting slide material is created in cooperation with the English language teacher. Concentrating intensely on a technical system together with high quality written and oral reporting using the English language improves the learning outcome of the both courses. Both teachers and students have perceived the integration of the courses as a positive factor. [3]

This example covered a foreign language, English. However, during the previous year there "The basics of production technology" course was integrated with the "Finish language and communication skills" course, with similar positive feedback from both the teaching staff and students partaking in the course. Another example is a complicated thermodynamical group assignment described below.

A group of students will undertake a literature based prestudy of a complicated thermodynamical process. They will be supported by several teachers and by the company professionals who have given the group assignment to IME. This work leads to a second phase, where part of the first group continues the work under guidance of the same professionals preparing and planning experiments. The students undertake the basic test rig engineering work and automation students undertake both the hard and software for the data collection and analysis. These experiments will be applied at a full scale pilot plant which in turn will be dimensioned and integrated to building automation and HEVAC (Heating, Ventilation and Air Conditioning) systems of a new office building. The roles of the partners in the later phases of the project are not yet agreed on, however, the three first steps will be undertaken by the strongly mentored student groups.

Another example of the syllabus integration is work already undertaken between IME and a partner company, an important process equipment manufacturer who moved its research plant to new place. The changes in the heavy and complicated test equipment, new layout new data collection system are done by a group of six engineering students. The engineering work of the mechanical changes, management on the manufacturing, instrument and sensor engineering, software production and testing, assembly management are all done under supervision of the company staff. All the participating students have been working in earlier project groups under same subject. The cumulative learning is giving good results for the company as well as valuable learning experiences to the students.

Most professional courses within the industrial management engineering study line at TUAS are taught in English. Furthermore all exercises are undertaken as project work in teams consisting of five students. This has also enabled the inclusion of exchange students within the degree programme: they are placed as members in project work groups to ensure that the working language really is English.

3 DISCUSSION

The need for a change in the pedagogic methods and in the way of doing is widely recognized. The problem usually is that the change does not start. The teachers may want to stay in their comfort zone or they may hesitate to start work with industry professionals. A lot of different methods and pedagogic tools as well as pedagogic research undertaken to provide application tools, have previously been presented to start the change. The problems faced in commencing the development process are also widely recognised. [4] [5]

Most of the teaching staff members are experienced specialists of the professional subjects they teach. In their eyes most of the pedagogic models are complicated, and rather theoretical. Their mission usually is to transfer some of their knowhow to the students, giving in the majority of cases less or little regard to psychological theories. Learning by doing, Problem based learning, CDIO, Eng 2.0 and many other complicated models are examples of solutions offer to enhance the engineering education system. The underlying idea in most is almost identical and same case examples can be presented as success stories of several different products.

The message here highlighted by IME at TUAS is: simplify, rationalise and put into practice. This message aims to simplify teaching to a more practical approach lowering the threshold for teachers to try new ways of doing. Innovation pedagogy means "licence to" experiment. Errors are accepted and learned from. The theoretical core is taught with traditional methods but as soon as possible the attention is turned to applying the theory, which in turn deepens the theoretical understanding and also locates the theoretical knowledge to the right context in working life projects. In short the process can be summarised as follows:

- Applications as early as possible
- Applications from working life
- Organize exercises as projects
- Always require oral and written reporting
- Combine knowhow of several teachers to each project
- Put students work together in international groups

Most of the students who carry out this type of work are highly motivated, which also has a positive effect on the teachers. The fact that teachers form continuous connections to working life updating their professional skills forms an integral part of this innovation process. This also brings the educational system and the working life closer together. The motion has started.

4 CONCLUSION

Engineering education faces many challenges identified by a number of institutions such as the CDIO and Engineering of the Future summit. This paper presents the ways in which the industrial management engineering study line at TUAS has used innovation pedagogy as a means to address these issues in a way to further enhance and develop a new approach to teaching whereby future graduates possess innovation competences: both the basic engineering skills as well as the interpersonal and teamwork skills essential for a successful career in a rapidly changing international business environment.

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157 ENTREPRENEURSHIP IN HIGHER EDUCATION - A SUCCESSFUL PROGRAM AT TELEMARK UNIVERSITY COLLEGE

S.T. Hagen[1] & H. Hasleberg[2]

1 Telemark University College, Porsgrunn, Norway, svein.t.hagen@hit.no
2 Telemark University College, Porsgrunn, Norway, harald.hasleberg@hit.no

ABSTRACT

The main objective of the entrepreneurship programme at Telemark University College, Faculty of Technology is to ensure the future of the Norwegian welfare society. In two courses at bachelor level the students learn how to use innovative tools and to have a more practical view on how to write a realistic business plan. In the 1st year, the students are trained for two intensive days at the Entrepreneur Camp in writing a sketch for a business plan, and in the 3rd year, the bachelor students can take the course Student Enterprise with 20 credits. Since 2004 we have been the examiners for 28 Student Enterprises and the results have been most successful. Our students are the most often winners in national competitions in Norway, and have participated in the competition Junior Achievement-Young Enterprise, Europe six out of seven times. The students work in groups of 3-6 members and they have to come up with and develop their own business ideas. The students have more responsibility and are expected to seek knowledge and competence from mentors and other networks in the industry. The entrepreneurship programme is continuously being developed and improved through a good interaction with students, former students, mentors and industrial partners.

Keywords: Innovation, Student Enterprise, Business Development, Entrepreneur Camp

1 INTRODUCTION

Competence in entrepreneurship and innovation is a crucial contribution to improvement and simplification both in public and private companies. The intention of the Telemark University College, Faculty of Technology (TUC-FT) is to educate the students with innovative tools in order to make them capable of starting new enterprises after graduation. Norwegian business has a great demand for new graduate students with knowledge and competence in entrepreneurship.

The Ministry of Education and Research in Norway has emphasized the importance of an innovative and sustainable business. The Action Plan "Entrepreneurship in Education – from Primary School to Higher Education 2009-2014" written by three ministries [1] summarizes the need of entrepreneurs like this:

The goal of this plan is to extend and strengthen the quality of entrepreneurial training on all levels and fields in the educational system. Norway will be an international pioneer when it comes to entrepreneurship in education. By stimulating attitudes, knowledge and skills of pupils, students and teachers on all levels, an entrepreneurial trend will be developed. In other words;

by strengthening the personal qualities and attitudes of the individuals, will again stimulate co-operational skills, innovation, persistence, creativity and faith in personal decisions.

Entrepreneurship at TUC-FT is an educational tool with its own teaching methods and learning contexts. The students will gain a more practical approach to learning; they will have more freedom and take more responsibility for themselves. The students must build their own networks, seek information and gain knowledge on their own.

Entrepreneurial education at TUC-FT is based upon the following educational platform: Prepare man for development, and prepare development for man. Go to your fellow man, live with them, love them and learn from them. Start with what they have, build upon what they know and can do, and as time passes by – when the work is done – they will rejoice to say: – I have done it myself. (Lao Tse, Chinese philosopher, 500 BC.)

The goals of the Student Enterprise course are to:

- Provide a form of learning with a high degree of freedom and independence, but with clear objectives and milestones
- Increase graduation rates among engineering students
- Lead to increased learning through intercourse and network building. Less focus on lectures
- Provide motivation and tools to young entrepreneurs
- Increase the knowledge of entrepreneurship in employees and utilize multidisciplinary expertise between different departments in a better way
- Provide knowledge and expertise in business establishment, management, closure, board responsibility, law, budget, accounting and registration at the National Register Centre

2 IMPLEMENTATION OF PEDAGOGICAL IDEA

Twelve skilled lecturers supervise the Student Enterprises at TUC-FT in the year 2011/2012. Five out of six lecturers have been supervising since the beginning in 2004. Every year new supervisors are being trained within the faculty. The supervisors possess complementary knowledge through their experience with innovation, industry-related business, R&D and educational development work.

We provide specially designed seminars to the students through a close co-operation with the Department of Business Administration and Computer Science and the Faculty of Arts, Folk Culture and Teacher Education [2]. This co-operation strengthens the multidisciplinary expertise. The engineering students are provided with guidance and given lectures with exercises in topics such as economy and design. They are lectured by both students and teachers from faculties other than the Faculty of Technology.

Course coordinators from all three faculties have, together with Young Enterprise Telemark (YET), formed a coordinator group which arranges events such as the exchange of experiences and competitions. At these competitions the panel of judges always consists of external examiners, representing businesses such as the banking industry, development companies and investment companies.

Telemark County Council and the TUC have signed a partnership agreement. The agreement applies to several areas of cooperation, including entrepreneurship. Telemark County Council has designated YET as the operator with the focus on entrepreneurship in education in Telemark. TUC is collaborating with several industrial stakeholders regarding the Student Enterprise and the Entrepreneur Camp. Among these is the Confederation of Norwegian Enterprise, Telemark (NHO Telemark).

Other examples of interaction with business and industry are through mentoring and lectures. In this context a mentor is an experienced supervisor from industry or other relevant organisations.

The Entrepreneur Camp started in the autumn of 2010 as a mandatory event for all students at TUC-FT in the 1st year and is done in partnership with local businesses, YET and Innovation Norway, Telemark. Thus the new students will have a taste of entrepreneurship and innovation before they eventually will have the option of choosing the Student Enterprise course in the 3rd year. Typically, about 170 students participate.

External mentors provide the students with the background information they need in order to solve their task. During two days, the students receive training in creativity and in solution-orientated work in groups of four to six people. Each group must work together in order to find the most innovative solution. Guidance during the process increases the students learning outcome and contributes to seeing the value of network creation. Representatives from local enterprises contribute as supervisors and examiners. In the final stage of the Entrepreneur Camp the students present their solution to the jury where the best will be awarded.

The national guidelines for engineering education [3] introduce a mandatory new 1st year course called 'Introduction to engineering profession practice and methods'. On p. 38 in reference [3] we find the following quote:

The students are to learn the engineering profession by becoming familiar with the engineer's work and working methods, and thus be aware of the consequences of different technological solutions. An important aim is to motivate the students to seeing engineering in a wider context and to develop a comprehensive, open and inquisitive approach to knowledge.

TUC-FT will support this objective by having the Entrepreneur Camp as an integrated part of this new course.

The Student Enterprise is an optional 20 credits course covering one year which gives the students knowledge about business establishment, including the startup, management and liquidation of their enterprise. For help and support along the way the faculty will provide two supervisors, and mentors from business life will also contribute. The students gain valuable knowledge and skills of entrepreneurship and teamwork and how the market responds to their business ideas. Entrepreneurial education is a rewarding experience, not only for the students themselves, but also for the faculty, lecturers, business and public sectors.

Continuous improvement of the course programme is being conducted by taking into account written evaluations from the students, and through meetings between students and supervisors. The annual schedule for the Student Enterprise at TUC-FT in 2011/12 is shown in Table 1. All events are mandatory except those in parentheses.

TABLE 1. Important events of Student Enterprise 2011/12.

Text	Date
Information to all 2nd year students	Mar 2011
Application deadline	14 Apr 2011
(Brain Storming Seminar, Preludium 2012, Norsjø Hotell, Akkerhaugen)	2 May 2011
Official start	29 Aug 2011
Kick off, Rauland	1-2 Sep 2011
(KAN – Women Ambitions Network, Oslo (only for female students))	26-28 Oct 2011
ICT Seminar in Student Enterprise, Skien	1 Nov 2011
Thesis with business plan	21 Nov 2011
First oral examination of Business Plan, 10 minutes	2 Dec 2011
Presentation Seminar, 2 Minutes to convince competition	15 Feb 2012
Venture Cup, Business Plan deadline, Norway East	9 Mar 2012
(Venture Cup, Norway East Championship, Oslo	19 Apr 2012)
Telemark County Championship Student Enterprise, Bø	3 May 2012
Deadline of the notice annual general meeting	9 May 2012
Deadline of the annual general meeting	23 May 2012
Final thesis with business plan and annual report	24 May 2012
Web site deadline	1 Jun 2012
Final examination for those who are not attending the Norwegian Championship	4 Jun 2012
(Norwegian Championship Student Enterprise, Oslo)	6-7 Jun 2012
(JA-YE Europe Enterprise Challenge, Skopje, Macedonia)	4-6 Jul 2012
(Norwegian Championship of Venture Cup, Oslo)	X Sep 2012

In the implementation and monitoring of the Student Enterprise course, the TUC-FT emphasizes these principles:

- A strong emphasis on using milestones for keeping a focus, motivating, ensuring progression, evaluating and giving feedback
- A high awareness that the Student Enterprise students themselves are the core of the skill building
- Evaluation of the Student Enterprise concept in cooperation with our partners
- Feedback from business and industry which inspires and motivates the students. The students learn that open dialogue is developing, non-threatening and necessary
- A clear and distinct strategy concerning the media. Encourage the students to use the media constructively
- Utilizing the potential of the supervisors. Diversity and experience among the supervisors and mentors are important factors
- To be clear, direct and understanding when handling conflicts, while avoiding demoralizing actions or comments
- To prepare ordinary technical projects for students who cannot cope with the pressure and/or students who regret their choice
- To keep a good information flow in the virtual classroom (Fronter)

- To be aware of ethical and environmental issues as new products and services are presented
- To ensure a sense of community among the students and the supervisors. Although competition mentality is encouraged, the most important objective is to acquire skills concerning entrepreneurship and innovation
- Monthly meetings between the supervisors where on-going and upcoming problems/ challenges are discussed and information is exchanged.
- Annual seminar for TUC supervisors

3 RESULTS AND EXPERIENCES

Since the start in 2004, we have received feedback from several students indicating that we as a faculty have succeeded in following Lao Tse's principle. Egil Rypestøl from Teach SB said: "I experienced that I can achieve whatever I want if I really go for it". Another former student, Ivar-André F. Næss from the student enterprise KiTT SB, said: "The foundation of our establishment is based on independence and internal resources".

The coordinator group at TUC has during 2011 contributed to the creation of a "getting started" organisation named Start. Start is an organisation run by students which encourages entrepreneurship and innovation among students at universities and university colleges in Norway. Start organizes a competition both on a regional and national level which is called the Venture Cup.

The Student Enterprise at TUC-FT has kept a high quality level since the start. The number of participating students has varied, with a somewhat low participation during the period 2007-2009, see Figure 1. The numbers have increased significantly in the last two years, and as of today, there are 41 registered students divided into 10 groups. After application deadline 16 April, 2012 38 new students and 10 groups have applied for Student Enterprise 2012/13.

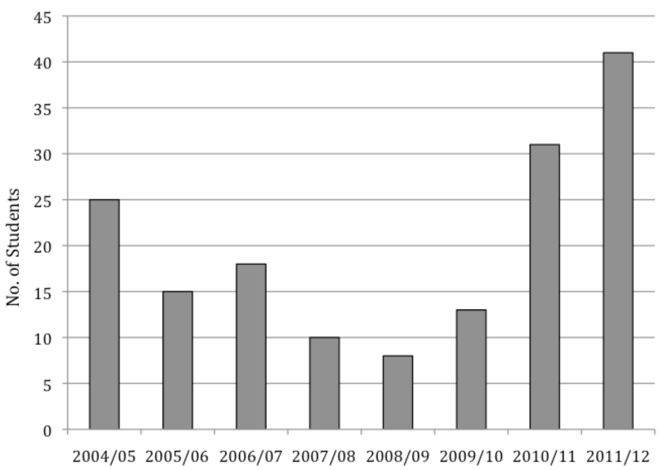

FIGURE 1. *No. of students who have graduated in Student Enterprise.*

The Student Enterprises at TUC-FT has received five awards in the European Championship, 31 awards in the National Championship and several other awards in regional competitions.

TABLE 2. Student Enterprise titles and awards won by TUC-FT.

Text	2005	2006	2007	2008	2009	2010	2011
JA-YE Challenge		1st		3rd		2nd	
European SE Best Selling Award	1st						
Best International Potential						1st	
National Championship	1st,2nd	1st,2nd	1st,3rd		2nd	2nd,3rd	2nd
FERD	1st	1st	1st	1st		1st	1st
"Manager one day" Award	1st	1st	1st				
Nordea's Award		1st	1st				1st
Innovation Award		1st	1st			1st	1st
Design Award			1st				
Manpower's Award				1st			1st
Tax Administration Award					1st		
NHO's Award							1st

A former Student Enterprise student, started the limited corporation Grenland Rail AS after graduation in 2005. This enterprise has 13 employees and the turnover in 2011 was 3.8 M€. Grenland Rail AS won the Gazelle Award for Telemark County in 2010. The Gazelle competition includes all enterprises in the county and is characterized by a focus on growth, profit and good financial audit remarks. In 2011 Grenland Rail AS was ranked as the eighth best company in Telemark County. This is so far our best example of our students succeeding in business after taking part in the Student Enterprise.

Research on Student Enterprises and other entrepreneurial education shows that these students will have a higher success rate in the establishment of new businesses than other students, see e.g. reference [4]. One half of our engineering students are people with trade certificates in completed apprenticeships and whose study programme is specially tailored for such applicants. These students have the highest participation rate in the Student Enterprise. In references [5] [6] it is explained how students with job-related experience may have a better understanding of entrepreneurial skills than students coming directly from theoretical upper secondary school.

We have experienced that the media and the public have greatly appreciated our efforts in this field. 116 articles about the Student Enterprise at TUC-FT have been registered in newspapers, magazines and on edited web pages since 2005.

The entrepreneurial education at TUC-FT will be further improved from autumn 2014 when a new 10 credits course will be introduced. This must be viewed in the context of the new curriculum for engineering education which takes effect for students starting autumn 2012 [3]. The new curriculum states the following learning outcome:

The description of the learning outcome in the regulation §2 LU-F-5: "The candidate can contribute to creativity, innovation and entrepreneurship through participation in the development and implementation of sustainable and socially beneficial products, systems and/or solutions." See p. 9 [3].

The most important experiences can be summed up as follows:

- Through creative exercises the students develop their own ideas which are not a product of academia or business and they refine these ideas in/through a business plan
- TUC-FT has been known for its project-orientated engineering education since 1982. The Entrepreneur Camp and the Student Enterprise are innovative and progressive ways of project-orientated education
- Student entrepreneurs are offered guidance through enterprise establishment, even after graduation, which reduces the risk of bankruptcy or liquidation of the company
- The students realize their importance in the creation of workplaces and the material value for the community/society
- Many students show greater learning benefit by participating in entrepreneurship education than from oral lectures
- Teachers who participate as supervisors in the Student Enterprise course and/or the Entrepreneur Camp expand their educational tool box

4 CONCLUSION

The entrepreneurial education at TUC-TF has continuously improved since the start and has proven to be successful, with very good results for the Student Enterprises of the TUC. Feedback indicates that entrepreneurial education is important for future business establishment and enhances the quality of future engineers. The Action Plan from the ministries and the new curriculum for the engineering study programme show a strong indication that TUC-FT is heading the right way.

5 ACKNOWLEDGEMENTS

Young Enterprise, Telemark is acknowledged for its support and encouragement. The Entrepreneur Camp was started autumn 2010 as a result of the project at TUC called Young Entrepreneur. This project is supported by Innovation Norway and it is managed by senior lecturer N. P. Hovland.

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160 CONCEPT-BASED TUTORING SYSTEM FOR ON-LINE PROBLEM CENTERED LEARNING

James H. McClellan[1] & Gregory A. Krudysz[2]

1 Georgia Tech, Atlanta, GA, USA, jim.mcclellan@gatech.edu
2 Georgia Tech, Atlanta, GA, USA, krudysz@ece.gatech.edu

ABSTRACT

Among different theories of learning, the importance of repeated retrieval advocated by Karpicke and Roediger is appealing for teaching and learning in core engineering subjects. Recent research proposes a model for the time-spacing needed when doing repeated retrievals. These ideas are relevant for on-line systems that are being developed and marketed for tutoring, testing and homework in core science, math and engineering subjects. We have been developing a web-based Intelligent Tutoring System (ITS) for an introductory signal processing (SP) course built around the concepts needed in this Electrical and Computer Engineering foundation course. ITS features two databases: one holding all the questions tagged by concepts, the second containing measurements of student interactions. The student interface is minimalist with a question mode and a review mode. The instructor interface has tools for monitoring the total scores of an entire class and reviewing the answers of individual students on each question. The designer interface provides a capability for creating and editing questions, as well as making assignments by grouping sets of related questions. Two modes are available: a self-guided self-paced practice mode where all questions are presented by concept name, and a scoring mode where question sets are presented usually with a deadline due date. ITS has been used for four semesters in the second-year undergraduate SP course at Georgia Tech – more than 100,000 questions have been answered by over 400 students. Student feedback has been generally positive because we have typically created assignments that amount to quiz-review by offering the multiple retrieval approach when studying.

Keywords: Concept Based Learning, Tutoring Systems.

1 INTRODUCTION

In [1], tutoring is described as a sequence of learning opportunities where students encounter episodes with the goal of increasing their understanding of a specific concept, also referred to as a "principle". Naturally, a full mastery of a concept requires many learning opportunities whereby the underlying structure of a concept can be appropriately understood. The benefits of sustained practice, emblazoned by the "Power Law of Practice" curves, [2] demonstrate the relationship between repeated trials and reaction time, namely stating that with linearly increasing trials, the task related reaction times decrease somewhat exponentially. Studies on memory formation and recall [3] [4] have led to similar observations about retention, captured by the "forgetting curve", empirically establishing that acquired knowledge degrades and exponentially fades with time, often as memory cues become inaccessible. Hence, with greater experience learning becomes easier on related tasks, often summarized by the proverbial education motto – "practice makes perfect", however knowledge needs to be revisited to cement educational gains.

Perfection aside, educators have a stake in student progress on all given concepts, via assignments, the final exam, or other exercises that demand the student to recall and correctly apply the newly acquired knowledge. Progress is often measured by the degree with which a student is able to apply the knowledge to unseen, but related, problems or to work a problem backwards (reverse engineering), or to arrive at a solution with different underlying assumptions. These demonstrations of knowledge transfer serve to illicit an impasse in learners which occurs when a student realizes to possess incomplete understanding of a specific piece of knowledge and hence is motivated to take an active role in constructing a better conceptual understanding.

Different concepts will demand formulating different structures; hence multiple learning opportunities that encourage the formation of useful associations of reinforcing concepts ought to ultimately lead to deeper learning. Although the "read more – know more" dictum is well entrenched in today's engineering curriculum, recent research [5] [6] on repeated testing suggests a more effective learning style with the retrieval practice strategy preferred over encoding, e.g. studying. "Retrieval practice is a powerful way to promote meaningful learning of complex concepts commonly found in science education." [6] During testing, a student's knowledge is impromptu assessed and prompted for recall, and conceptually relevant information must be selected and retrieved. Learners themselves are forced to reason about the problem and in the process reconstruct and consolidate knowledge which itself enhances learning.

In fact, retrieval practice has been found to be more effective in conceptual learning than the act of constructing concept maps as part of a learning activity. Whereas concept map building encourages the learner to increase the number of known concepts and form associations among them, repeated testing has the added benefit of promoting cue building required for retrieval and selection. "In free recall, subjects must establish an organizational retrieval structure and then discriminate and recover individual concepts within that structure. Retrieval practice likely enhances the diagnostic value of retrieval cues, which refers to how well a cue specifies a particular piece of knowledge to the exclusion of other potential candidates." [6] It is this repeated conceptual search and retrieval process which educators hope to foster that will lead to a student's long-term recall and retention of the subject material.

Traditionally, human tutoring has provided extensive educational scaffolding by guiding students through problem solving activity. Tutoring is most effective when tutors help students to stay on a correct path, but allow students to provide their own explanations. Studies of human tutors indicate that guided explanations by tutors themselves may not be as helpful as once thought, but instead "tutorial behaviour that gets students to think, such as generating opportunities for impasses or giving zero-content prompts, may be the key to why tutoring is so effective." [1] These findings are corroborated by the self-explanation effect, which stress the importance of prompting the student for inferring and integrating possible solutions to a given problem, similar to recall retrieval practice.

Testing is a repetitive task best handled by computers; hence supplementing education with computer-based tutors is a way of providing ample learning opportunities for students. Developers of computerized tutors have grappled with the task of "how to choose what is taught, how to present it, and how to sequence the material" [7]. Recent research has begun modelling student education by looking at the latter task, namely the scheduling of learning episodes and the constraints imposed by learning new material and reviewing what has already been studied. This sequencing problem lends itself to what is known as the spacing effect, which stipulates that studying is more effective when spread over time. The benefits of periodic review of the newly learned material through testing lead to re-organization and generalization of the student's knowledge essential for long term concept retention.

Ultimately, a computer driven tutor may also be suited for the task of student assessment, where the educational goal is "to get students familiar with a certain set of educational units by a particular point in time" [7]. Already a few schools have begun exploring the idea of issuing skill-based certificates, such as MIT's merit badges, to on-the-job adult learners seeking to upgrade and expand their skills. We are entering the era of algorithmic education with the promise of inexpensive computer-based tutoring sessions that adapt to each student's needs and abilities in real time. Intelligent tutoring systems are set to revolutionize the way students learn to solve problems and, therefore, carry serious implications for the future nature of formal engineering education.

2 ITS

At Georgia Tech, we have been developing a web-based tutoring system (see Figure 1) called the Intelligent Tutoring System (ITS) [8]. The underlying educational goal of the system is to foster conceptual learning through repetitive questioning keyed to a specific concept(s). ITS has been deployed as part of a second-year signal processing (SP) course in the School of Electrical Engineering whose content is based on the "Signal Processing First" textbook. The course material introduces abstract "signals and systems" concepts supported by mathematical equations and interrelated conceptual dependencies which are often difficult for students to grasp as they cannot be easily visualized. The required development of the conceptual proficiency is representative of and applicable to the broad engineering problem solving skills and hence has served as a direct and effective introduction of computerized tutoring into engineering education.

Systems like ITS must have two interfaces: one for students, another for instructors to support administrative and editorial tools. The design of the student interface is mini-malistic, with just four activities: navigation, question-response, scoring and review.

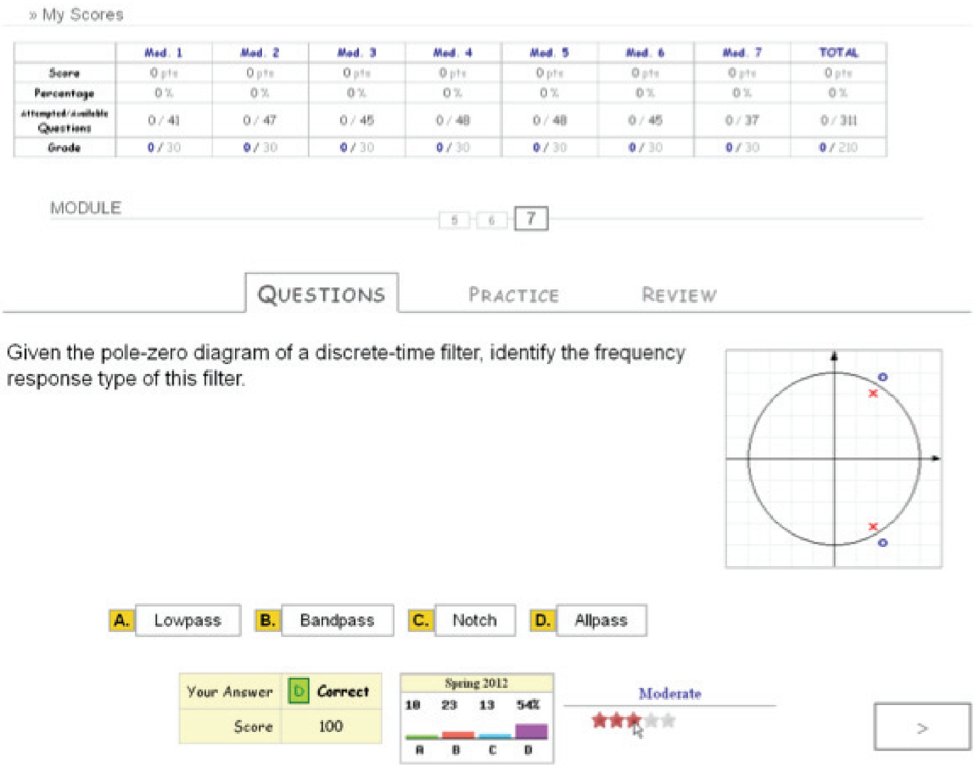

FIGURE 1. *ITS submitted multiple-choice question with My Scores tab.*

2.1 ITS – Student Interface

Navigation: At the top, students can select modules that group questions according to pre-selected tags or other criteria. At the moment, modules organize related questions in correspondence to textbook chapters, concepts, or specific class topics designated by the instructor. Modules provide a convenient way for structuring assignments that can be scheduled to open and close at desired times throughout the duration of a course.

Question-Response: Questions grouped within each module are shown under two different modes: the Practice tab and the Questions tab. In Practice mode students select question sets from a list of concepts for self-guided and self-paced study which might serve as preparation for the scoring mode. By design, each question becomes a learning opportunity targeting one particular concept, although multiple questions can address the same concept, multiple times. In effect, the pedagogical goal of ITS is to present the student with repeated conceptual tests, in order to motivate recall and cue selection required for matching and retrieving the designated concept. Learning through time-delayed repetitive practice is in stark contrast to a "single-shot" style, whereby students learn a concept, get tested, and are expected to remember.

Under the Questions tab, questions are presented in a random order where student answers are graded and must be completed by a deadline for scoring. Figure 1 illustrates the student view in Questions mode. An ITS assignment might contain many questions. For instance, over the past two semesters of the SP course, students were required to answer correctly 24 out of 40+ questions available per module to earn full credit. This strategy does not penalize students for making a few errors because the module typically contains several similar questions and these repeated questions offer later opportunities to be answered correctly. This approach allows students to take charge of their own learning, encouraging them to move on when failing to generate a correct self-explanation, and to retest their understanding unhindered by the potentially negative outcome. Students can learn at their own pace; those requiring many learning opportunities can build-up their knowledge from a larger sequence of questions, whereas quick learners may need to solve only the minimum number of problems in order to demonstrate their proficiency. Currently, there are over 2,000 questions in the database consisting of multiple choice, matching, and computed questions. Multiple choice and matching questions are presented in randomized states, while computed questions are parameterized to a range of variables. Module-specific questions are served at random from a pool of related questions and each question can be taken only once. Since conceptually unfamiliar or difficult questions will elicit an impasse during each problem solving session; ITS permits users to skip questions and return to them once they have constructed a better understanding of that concept.

Scoring: Upon answering a question, students are presented with a score ranging from 0 to 100, with a possibility of earning partial credit. In order to motivate self-explanations by students, ITS does not provide an answer for multiple choice or matching problems, but instead shows a class distribution of the submitted answers for each problem. For computed questions, ITS does provide an answer with an acceptable tolerance in the hopes of motivating students, if needed, to go back and retrace their calculations and arrive at the correct answer. In addition, students have the option of rating each question based on perceived difficulty. The rating is on a 1 – 5 Likert scale and provides a secondary indicator of student understanding of a particular concept. In addition, students can keep track of their progress via the My Scores tab, which tabulates module statistics. For each module – the scores, the number of attempted and available questions, percent completed, along with the projected grade are displayed.

Review: The Review tab allows students to review the already taken questions in each module. Questions are presented in the order answered, preserving the sequence of learning opportunities encountered by the student. With the aid of a slider users can quickly search and navigate across questions to review previously taken questions and also see how others in the class have answered. For the unrated questions, students have the option of rating the difficulty of the problem after revisiting it.

2.2 ITS – Instructor and Designer Tools

The instructor mode in ITS supports content creation, module creation, and allows educators to track student activity. Questions can be authored in ITS with the help of a web-based question editor and later grouped and associated with an assignment or a module. The profile view offers instructors the ability to monitor class participation and progress with a detailed view of each student's online activity.

Profile View: The profile view summarize ITS class activity by listing points earned and the fraction of students who have completed module assignments along with those who have reached full credit. A detailed profile of student activity is available for each student, where the sequence of questions answered is displayed (see Figure 2). In addition to recording student answers, ITS logs question scores, event time-stamps, duration spent answering each question, the configuration of the question, and the question difficulty ratings. The profiler is useful for instructors to keep track of student progress and in helping students reason about their submitted answers.

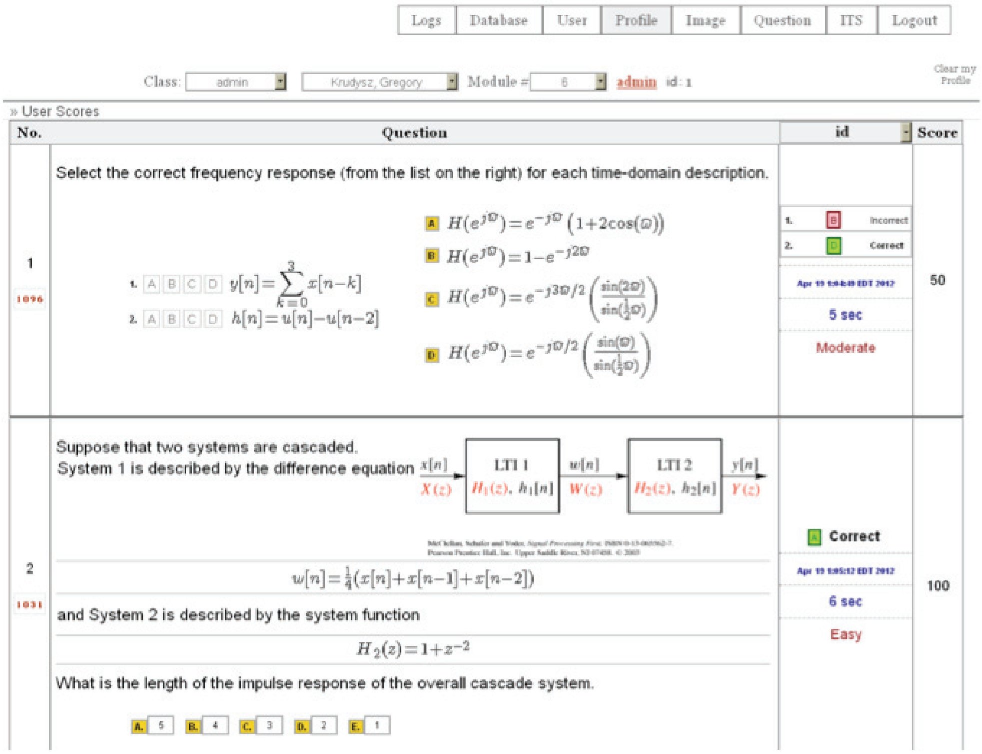

FIGURE 2. *Instructor view of a Student Profile.*

Question Editor: ITS is a question driven environment, hence its impact on learning outcomes is in large part based on the quality and applicability of the questions keyed to the course. The editor enables question authoring tools to create, clone, edit, publish, search, and share questions (see Figure 3). Currently, ITS supports the creation of five question types: multiple-choice, matching, calculated, short answer, and paragraph. Recently, calculated questions have been extended to support a multi-part format, where multiple sub-questions are associated with one question statement. Existing ITS questions can be easily cloned and modified to expedite the question creation process with the addition of revised versions. Question content is edited by either altering question parameters or by selecting the appropriate question fields and modifying the entries with HTML or LaTeX supported text. In addition, images can be uploaded either from the author's computer or from the ITS server-based image repository.

Tags: ITS links modules, concepts, and questions with a set of mutually supporting meta-data descriptors, or tags. The relevant content is labelled with tags to simplify and expedite the searching, selection, and extraction of information from the database. ITS distinguishes between two types of tags: conceptual tags which serve to describe the content, e.g. questions, images, or equations, and system tags which are associated with content organization and structure, e.g., a "chapter01" tag. Questions can be tagged in the question editor with the aid of a search window or by adding new tags to the system. In Figure 3, the z-transform tag is selected from the "z" search results.

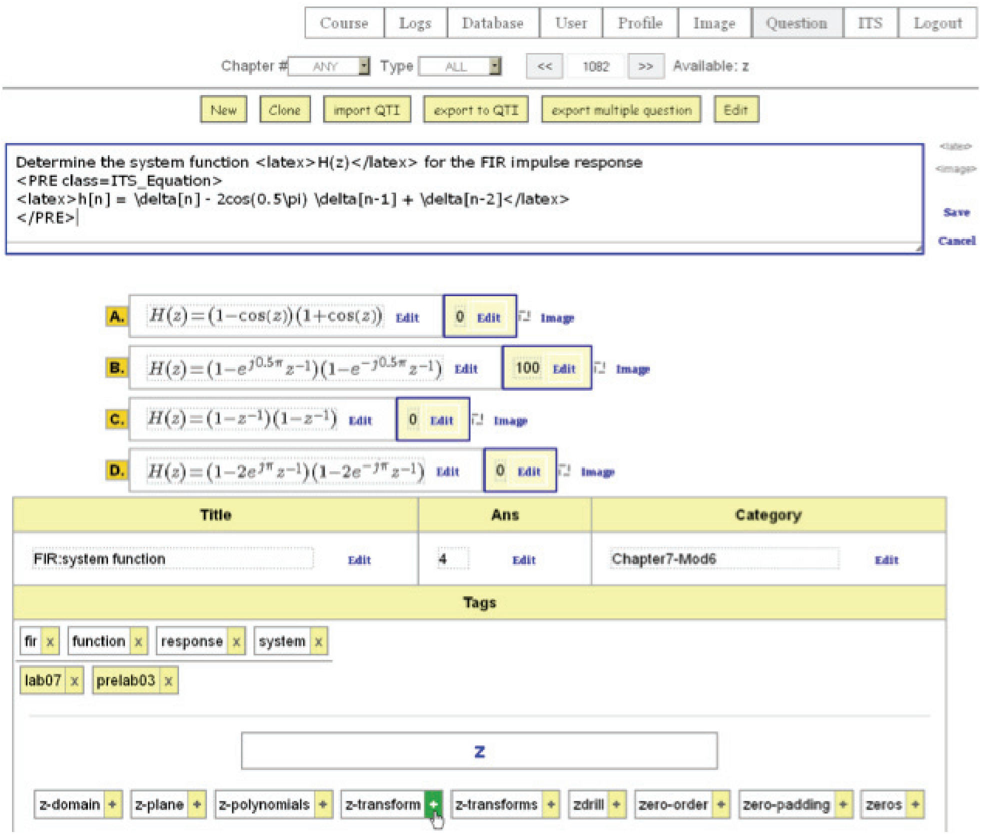

FIGURE 3. *ITS Question Editor: Multiple-choice question with the tag browser.*

Import-Export: ITS questions can be shared across different educational systems via the IMS Question and Test Interoperability specification (QTI). QTI is an XML based standard format for the representation, exchange, and delivery of question content in a neutral format. The ITS question editor supports importing and exporting of QTI questions as well as packaging ITS questions according to pre-selected filter criteria.

3 RESULTS AND DISCUSSION

Student Survey Feedback: Student reaction to ITS has been generally positive as many students use it as a mechanism to test their understanding and welcome the opportunity to practice and further enhance their skills. Asked during exit course survey consisting of 5-point Likert scale questions, to respond to the question "The ITS questions were helpful in my learning" – 81% of respondents agreed ("Strongly Agree","Agree") and 6% had an unfavourable opinion. Student sentiment was conveyed by the following comment – "The majority of the questions on ITS are very good and help with the actual working of problems; concepts are covered in class while the actual working of the problems are supported and solidified in recitation and ITS". When solicited for future improvements, students asked for more examples, hints and detailed solutions.

Data Collection & Usage: Over the past two semesters, over 400 students have collectively recorded over 100,000 question sessions, where approximately 15% of the questions were rated by students for difficulty. Each module consisted of questions grouped along textbook chapters and students were given a window of roughly three weeks to earn the required number of points. On average, students attempted 91% of the available questions, and 82% of the students managed to earn a full-credit. At present, ITS is a testing platform with data collection capabilities. To serve as an effective tutoring system, student responses must be used to adapt in real time using a student model based on statistical data-mining that infers the "learner-state". Currently, we are working to deploy ITS as an open-source project and building a national database of questions, through the Signal Processing Education Network project.

4. ACKNOWLEDGEMENTS

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161 BRIDGING THEORY AND PRACTICE: AN INQUIRY-BASED COURSE IN MATHEMATICAL MODELLING

Dag Wedelin[1] & Tom Adawi[2]

1 Chalmers University of Technology, Gothenburg, Sweden, dag@chalmers.se
2 Chalmers University of Technology, Gothenburg, Sweden, adawi@chalmers.se

ABSTRACT

Engineering students often fail to see the connection between mathematics and other subjects, sometimes leading to the belief that mathematics is not relevant for them. To bridge this gap between mathematical theory and practice, we have designed a course in mathematical modelling and structured problem solving. The course is based on the same inductive philosophy as inquiry-based learning and problem-based learning, and centred around 35 small and realistic problems, solved in pairs. With several smaller problems the students get to practice on the different aspects of the problem solving process several times during the course. The teacher mainly facilitates the learning process by asking the right question at the right time. A range of methods was used to evaluate the course. After taking the course, most students express and demonstrate a fundamental change in their abilities to "think mathematically", in their understanding of the nature of mathematics and its role in their future profession. The course was recently awarded the Chalmers Pedagogical Prize.

Keywords: Mathematical modelling, problem solving, inquiry learning.

1 RATIONALE AND METHODOLOGY FOR THE COURSE

"Mathematics is a living subject which seeks to understand patterns that permeate both the world around us and the mind within us" [1]. However, engineering students often fail to connect and apply what they have learned in introductory mathematics courses to other subjects [2], sometimes leading to the belief that mathematics is not relevant for them. This gap between theory and practice results from fundamental differences between what scientists or engineers "do when they solve problems and what they tell students to do when they teach problem solving" [3]. Stice argues that the main reason why students have trouble applying what they know to novel situations is that the teacher seldom models the entire problem solving process, including assumptions, alternative strategies and evaluation of results [4].

There is also a growing body of research demonstrating that students learn more from approaches to teaching that more actively involve the students in the learning process [5,6]. Bonwell and Eison, who popularized the notion of active learning, emphasize that "to be actively involved, students must engage in such higher-order thinking tasks as analysis, synthesis, and evaluation" [7]. A plethora of active learning methods have been described in the literature but a fundamental distinction can be made between deductive and inductive methods. Prince and Felder note that "traditional engineering instruction is deductive, beginning with theories and progressing to the application of those theories. Alternative teaching approaches are more inductive. Topics are introduced by presenting specific observations, case studies or problems, and theories are taught or the students are helped to discover them only after the need to know them has been established" [8]. In their article, they review the existing research evidence regarding the effectiveness of six of the most commonly used inductive teaching and learning methods – inquiry-based learning, problem-based learning, project-based learning, discovery learning, case-based teaching, and just-in-time teaching – and conclude that "inductive methods are consistently found to be at least equal to, and in general more effective than, traditional deductive methods for achieving a broad range of learning outcomes".

In this paper, we describe the design and evaluation of a course in mathematical modelling and structured problem solving, given to second year students in Software Engineering and related programmes, see [9] for details. The overall aim of the course is to target the generic skills needed to deal with real-world problems in science and technology, by developing two essential skills: the ability to translate real-world problems into mathematical problems (i.e. mathematical modelling); and the ability to systematically attack complex and unknown problems (i.e. structured problem solving). In contrast, the present curriculum at Chalmers – especially with respect to mathematics – is to a large extent about solving problems that are already formulated, using given methods. The aim of the course makes it natural to base the teaching and learning in the course on the same inductive methodology as inquiry-based learning (IBL) and problem-based learning (PBL).

2 PROBLEMS AS DRIVERS FOR LEARNING IN THE COURSE

So we have used an inductive approach to teaching and learning in the course, meaning that, for each topic, the learning process is initiated by a problem that provides context for learning through exploration. The course is centred around 35 small problems that are solved in pairs. By using "smaller problems/groups" rather than "larger problems/groups" the teaching and learning method is closer to inquiry-based learning than problem-based learning [8]. An advantage of using several smaller problems – in contrast to one big problem/project stretching over a whole course – is that the students get to practice and get feedback on the different aspects of the problem solving process several times during the course. Another advantage of using a set of smaller problems is the variation in applications, models and problem solving approaches that can be highlighted. This variation helps students to see important similarities and differences across the problems, allowing for deeper learning.

How the problem is formulated has a lot to do with how effective the inquiry is for the students. Each problem in the course has been designed to be: realistic in the sense that it corresponds to a topic or situation that the students may encounter in the future; motivating in the sense that the solution is interesting and sometimes surprising; sufficiently challenging to force the student into real problem solving; and multi-purpose by meeting several different course objectives.

The problems have different character and complexity (i.e. how challenging they are), depending on the specific topic, and depending on what we think the students are able to handle in each case. Some problems are more structured and have a well-defined answer while others are more ill-structured and open-ended. It is often not clear how to tackle the problems, so an important part of the task is to understand the problem, make suitable assumptions and describe it more precisely.

3 SUPPORTING AND ASSESSING LEARNING IN THE COURSE

The course is organized in six weekly modules, see Figure 1, where the structure of a module is also shown. Each module focuses on a certain type of model. See [9] for details.

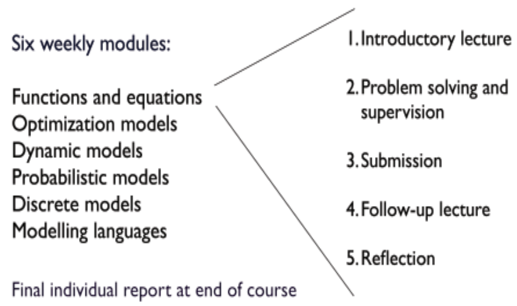

FIGURE 1. *Overall structure of the course.*

Supervision

Most students would probably not be able to solve the problems without sufficient guidance and scaffolding through the inquiry process [10]. Several studies have documented poor learning outcomes resulting from pure discovery learning which is a minimally guided, problem-centered method of teaching [11]. As Nilson puts it: "Constructivism has its limits" [10].

Continuous supervision is therefore a very important element in the course. The style of supervision is mainly Socratic – it mainly involves asking questions – to probe student thinking as well as to help students to discern what they know and what they need to know. At the same time we indirectly teach a method to supervise yourself.

We try not to give more help than needed; if this help is not sufficient, students can get more help by asking again. In this way we avoid that they are totally stuck, and we can hopefully accelerate learning and provide specific help to each group. We also remind students of general problem solving strategies, that the problem cannot be solved in a single step, and not to rush to the solution. There is also a need to encourage the students and convince them that they are capable of solving the problems, if they just learn to work in a certain way.

Introductory and follow-up lectures

In the introductory lecture for each weekly module, we provide a general introduction relevant for the problems of the week. We also teach general modelling and problem solving strategies [12,13], such as that of Pòlya [14].

In the follow-up lecture, we provide collective feedback by going through the problems, proposing good solutions, showing different approaches to solving the problems, and bringing up common mistakes or difficulties. Due to this feedback lecture, it doesn't matter so much if the students don't reach all the way to a solution of the problem. When they have spent time struggling with the problems, also weaker students are in a good position to appreciate the solutions, and may even learn more than those who were more successful. We encourage reflection by asking the students to compare their own solutions with the presented ones, and consider what they might do differently in the future. This reflection is to be written as a part of the following module. Another purpose of the follow-up lecture is to move beyond the specific problems, to provide additional perspective and draw general conclusions.

Formative and summative assessment

To pass a weekly module, the most important requirement is that the group has seriously attempted to solve the problems, but they are not required to reach any final or correct answers. We also require that the facts are correct and that the presentation is acceptable. In practice, these requirements mean that if a student agrees to participate in the course, and spends a reasonable number of hours, s/he can feel confident to pass. This is important to make the students relax and take interest in the real challenges of the course. Otherwise, it would be very stressful to present open and difficult problems, which may go beyond what a student is able to solve. It also reduces the motive for cheating.

By not formally grading the weekly modules and by providing significant feedback during the follow-up lectures, we are able to keep a normal course budget (we usually have about 100 students). Generally, direct interaction with students has been prioritized over time consuming marking and individual written comments.

In order to pass the course, the weekly modules and a final individual report must be completed. The general purpose of the report is to let the student reconsider and reflect on the course, and it is up to each student to decide how and what to write. Some write a relatively simple summary, others make quite remarkable analyses and reflections. The final grade is determined by the final report and a rough assessment of the modules, based on given quality criteria [9]. Disagreements are unusual but are resolved in a dialogue, where students can improve their report whenever reasonable.

4 A SNAPSHOT FROM THE COURSE

To better convey how the various elements of our pedagogical design come into play, we now give an example of a teaching and learning sequence in the course.

In one of the first problems, the students are asked to find a curve that fits a number of points provided in a table. No systematic method for doing this has been presented, and many students are confused. However, by asking students who are stuck if they have made a plot of the points, most begin to see how they might work (although it happens that some draw so carelessly that they start making false conclusions and are lost). The plot is shown in Figure 2.

After making the plot, those who so need are asked if they can think of examples of different functions. A common student question is: "Is it allowed just to do that?" By looking at the curvature, many students hypothesize the logarithmic function. When they ask for confirmation, we ask what they think the value of the function should be at 0 and infinity. They then usually discard their hypothesis by themselves. Another common student question is: “Is this good enough?” to which we ask if they are satisfied. Some students use software to find a polynomial, giving a very good fit.

In the follow-up lecture, a simple formula with an excellent fit is presented and different ways to find it are discussed. We also consider how other alternatives can be discarded, or why they are not preferable. Students also learn that what they have – or could have – discovered, is in fact one of Kepler’s laws. This observation opens up for a short historical background and reflection on the nature of scientific discovery.

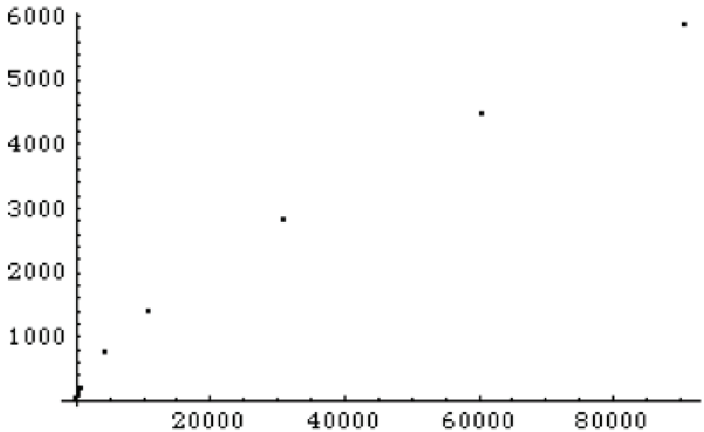

FIGURE 2. *Plot of data points for the example problem.*

Note how this single problem meets multiple objectives: to introduce curve fitting; learning to develop your own problem solving strategy; to recollect basic mathematical functions; to evaluate the quality of a model; to prepare for a later problem on the least squares method; and to provide a link to the history of science.

5 EVALUATING THE COURSE THROUGH TRIANGULATION

“Evaluation”, Ramsden states, “is a means of understanding the effects of our teaching on students’ learning” [15]. We have used a variety of (quantitative and qualitative) methods, or triangulation [16], in evaluating the course. These methods include: a questionnaire at the end of the course, using both numerical grading on a 5-point Likert scale and open-ended comments; probing of student understanding during supervision; analysis of solutions in hand-ins and analysis of reflections in individual reports; and focus groups.

When students enter the course, many of them know more mathematics than they are able to use, and they do not trust their own ability to “think mathematically” [1]. Formulas are seen as given once and for all, and often mathematics is seen as something where form is more important than content. Many students do not expect the course to be useful, and expect even more complicated calculations.

After taking the course, most students express – and also demonstrate – a fundamental change in their abilities to "think mathematically", in their understanding of the nature of mathematics and its role in their future profession. The learned concepts and skills are considered as generally useful. The following comment is representative for many of the students: "For the first time during my studies I was able to connect the course both with previous courses as well as with the kind of problems I can expect in my profession as an engineer". Comments like "I have never before thought about where the formulas come from", and "The course has lifted me to an entirely new level" are common. One of the most commonly reported experiences is that modelling and problem solving show them a new and more creative side of mathematics that is not just about right and wrong. Moreover, the students are surprised to see how very "simple" mathematics can be used to solve apparently non-trivial problems, and how their prior knowledge of mathematics, in unexpected ways, turns out to be useful as steps in the problem solving process. For the first time, many students realize how mathematics can be a part of their identity as engineers.

A contributing factor to the effectiveness of the course is the continuous supervision. Hattie conducted an extensive meta-analysis of studies investigating what actually influences student learning and he concluded that the most powerful influence is feedback [17]. The many hours spent on supervising students provide rich opportunities to see how the students work, and to give relevant feedback on their work. In our experience, the combination of small, relatively open and challenging problems and continuous supervision is a very effective method for discovering conceptual hurdles and substandard working practices. And these are surprisingly common. Why should we, for example, believe in the Pythagorean theorem? Here are some common student answers to the question: "it is well known", "it seems to work on many triangles", and "there are several different mathematical proofs". This range of answers naturally leads to a fruitful discussion about fundamental concepts.

With respect to working practices, many students are used to rush towards an answer without proper analysis; they are answer-focused [18]. But to become a successful problem solver it is necessary to analyze the problem to "unfold its meanings and discover its structure" [18]; otherwise you will get stuck. Hence, as Booker has noted: "a first task in developing problem solving often requires deliberate steps to break down the answer-focused behavior". A related problem is that many students do not recognize the importance of being careful. Students are often not aware of their limitations, because they have previously not encountered situations/ problems that reveal them, or because they have not themselves understood the nature of their own behavior.

Students regard the course as the best mathematics course in their education. It is considered demanding and at times also frustrating, although the percentage of students that pass is unusually high compared to other courses (about 90%, average 70%). Students ask for more courses like this one, and wonder why there weren't similar courses earlier in their education. In 2011, the students gave the course an average overall grade of 4.8 out of 5. The course was also recently awarded the Chalmers Pedagogical Prize.

6 SOME CONCLUDING THOUGHTS

The single most important contribution of the course is that it exists, and that it aims to develop two essential generic skills that have previously not been sufficiently represented in the curriculum at Chalmers: mathematical modelling and structured problem solving. A key characteristic of the course is also that it has a bottom-up design, with the course objectives in mind, rather than starting from an idea of how courses usually are delivered, or a particular method of teaching [19].

When comparing our pedagogical method to the ones used in other courses at Chalmers, one might say that the course represents an intermediate step between straightforward knowledge oriented courses and PBL-courses. Compared to the former, this course has a much higher emphasis on methods and skills for handling the unknown. Compared to the latter, the student encounters a wide range of problems and approaches, and learns to make appropriate distinctions and choices between them. So the controlled setting of this course, with a large number of varied problems that the teachers know well, can be seen to prepare the students for projects and other more independent work.

As teachers, it is encouraging and remarkable to see the positive effects of consciously teaching what has previously been missing (mathematical modelling and structured problem solving), how the pedagogical method really works, and how one can help students to overcome many of the hurdles that have previously crippled them. This approach to teaching is also very stimulating, so it is easy to be a good and engaged teacher in the long run.

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162 BEST PRACTICES FOR EFFICIENT STUDENT TUTORING, CASE: SPACEMASTER AT AALTO UNIVERSITY

Anja Hänninen[1], Tomi Ylikorpi[2] & Aarne Halme[3]

1 Aalto University School of Chemical Technology, anja.hanninen@aalto.fi
2 Aalto University School of Electrical Engineering, tomi.ylikorpi@aalto.fi
3 Aalto University School of Electrical Engineering, aarne.halme@aalto.fi

ABSTRACT

Graduating in an ideal study time is a relevant issue in Finnish universities. The academic freedom in the past years actuated extended study times. This case of the SpaceMaster program at Aalto University demonstrates that reduction in study times can be achieved. Active role of the program staff, team spirit and cooperation, with proper planning and arrangements are needed. Good results are gained with the help of individual and specified tutoring, but not without sufficient resources. Efficient communication and a prepared schedule help both the staff and the students. Progress of the studies and the thesis of each student, is supported in several ways. Five years of experience in the SpaceMaster program shows that with sufficient resources and with a right attitude graduating from a master's program in the ideal study time is possible.

Keywords: Tutoring, Master's program, Master's thesis, Erasmus Mundus.

1 INTRODUCTION

The challenges with completing master's degree in an ideal study time are as relevant today as they were in 1960s, when they were first raised as a politico-educational topic in Finland. Until then study programs comprised of fixed curriculum and schedule. The Academic freedom made students' own choices possible. Working and travelling alongside with the studies became usual. Since then several curriculum reforms have been executed in an attempt to shorten the study times with special measures. Universities have been obliged to renew degree structures, decrease students' work load, extend teaching periods and exam opportunities, as well as to improve student selection, develop teaching methods, increase efficiency etc. In spite of all these activities and reforms the study times remain long in most of the fields, and even extended in 1980s. Various reasons were found for it. In the early 2000s, the average study time for completing master's degree in the field of technology was 6.5 years. [1] [2]

The latest curriculum reform was executed in 2005 as a part of the Bologna process. It introduced the current degree structure with the three year bachelor's degree and the two year master's degree which was a significant change in the field of technology [3]. Expectations focusing on universities had also risen in the process. The first Erasmus Mundus program in Aalto University offered an interesting opportunity to try new methods in tutoring, and to show that it is possible to guide the students to graduate within the ideal study time.

This article presents a case of a master's program from which the students graduate within the ideal study time. It is executed alongside with a larger study program with extended study times. The article describes different aspects of tutoring and guiding concerning practical matters, studies and the thesis. The resources needed are also described.

2 ABOUT THE SPACEMASTER PROGRAM

The Erasmus Mundus Master Course in Space Science and Technology (SpaceMaster) is a 120 cr ECTS master course that provides research and professional-oriented modules and projects in space science and technology. During the two years of full-time studies, students obtain cross-disciplinary experience through courses and laboratory work in satellite control, space robotics, remote sensing, sensor data fusion, automatic control and multi-body dynamics. They also have the chance to participate in balloon, rocket and pico-satellite missions. They study at two or three of the six consortium universities in Europe, and complete double M.Sc. degree.

The consortium universities are Cranfield University, UK, the Czech Technical University in Prague, Julius-Maximilians-Universität Würzburg (JMUW), Germany, Luleå University of Technology (LTU), Sweden, Université Paul Sabatier Toulouse III, France, Aalto University School of Electrical Engineering (Aalto), Finland, University of Tokyo, Japan, and Utah State University, U.S.A. [4]

SpaceMaster students spend their entire first year together. Semester one starts at JMUW, and the second semester takes place at the LTU Space Campus in Kiruna, Sweden. The third and fourth semesters take place at one of the consortium's six European universities and deal with the area of expertise of the selected university. The fourth semester is dedicated to master's thesis research and writing.

The SpaceMaster was launched in 2005, among the first Erasmus Mundus programs.[5] The curriculum of the program has been developed commonly by all the partner universities. SpaceMaster has succeeded in recruiting both European and non-European students.

3 ARRANGEMENTS FOR THE SECOND YEAR AT AALTO

3.1 Program staff

The staff managing SpaceMaster in Aalto consists of the three key persons appointed to SpaceMaster tasks along with their steady tasks, and the teaching staff (TS). The program director (PD) professor is responsible for decision making and for supervising the theses. The tutoring teacher (TT) is responsible for the general teaching related matters as well as for the practical thesis related matters. The local coordinator's (LC) tasks are to take care of all the other practical matters, and of the administration. The teaching staff TS consists of the teachers of the courses, and of the thesis work instructors. LC and TT participate in the program consortium's common work, and communicate with the program's Main Coordinator.

3.2 Preparations before the students' arrival

The SpaceMaster students arrive at Aalto in September, and stay for a full year, until the end of August. A lot of arrangements are done before they even arrive. Preparations for admission start right after consortium has confirmed the second year universities for students, in April. LC in close collaboration with the Student services, the International student services, and the Accommodation services will provide the first hand information customized for SpaceMasters. It will be delivered along with the new degree student's Admission letter package. Special accommodation arrangements are made exclusively for Mundus students.

The guiding of new students begins in April with LC's email contact, concerning the accommodation and the admission. The communication, covering any practical matters bothering the students, continues over the summer months until the students' arrival. General topics of the communication are related to accommodation, residence permits, moving luggage from Kiruna to Helsinki, arrival at Helsinki, internship possibilities at Aalto, etc. Questions and concerns related to the thesis topics, thesis projects or course contents are responded by TT. In order to avoid small problems from growing into catastrophes, the key persons must show willingness to check the email also during the holiday season in July.

3.3 Upon arrival

The Aalto University Student Union as well as the profession student guild, offer their support by providing student tutors to meet the new SpaceMaster students welcome at the airport or in harbor, to escort them to the Campus and to locate their accommodation. One week of intensive introduction into Finnish language and culture, exclusively for Mundus students, gives a soft start for studies. The Orientation Days in the beginning of September provide the new international students a lot of useful information about studying at Aalto, about the practical study related matters and about Finland. Besides the general info, also departmental info is organized for the new foreign students.

Info about the practical SpaceMaster study related matters is also organized. The double degree, and the students' obligations to the two universities simultaneously are discussed, the schedule and the contents of the academic year are explained. They also meet the staff and learn about the facilities available in the department. The most important information is collected on the local Wiki site by TT. The site acts as a source of information both for the students and for the staff. Also the SpaceMaster alumni at Aalto act in valuable support of the students, not only concerning the studies and the thesis but also in introducing the university, the campus and the city.

3.4 Arrangements during the study year

The SpaceMaster second year studies at Aalto consist of the courses (30 cr ECTS) with specified contents, and of the thesis (30 cr ECTS). For providing students with essential knowledge and skills required for starting the thesis work, the course content specifying is essential. The specified updated schedule for the academic year is available on the local Wiki site. Knowing the study schedule with exam dates, seminars and deadlines since the arrival day is important for students' commitment to studies. The Wiki site also contains information about the degree structure, and about finalizing the thesis and applying for the degree. Though all information available on Wiki site, TT and LC must follow up and when necessary remind the students on certain deadlines, on filling in the forms to be returned on time for both of the double degree awarding universities. Especially during the last weeks of the study year, in August, extra support on keeping schedule is needed.

A special study and work room is allocated to students in the immediate vicinity of the laboratory facilities and of the offices of TT and LC. It enables a close follow up of students' working and study progress, and also helps students to take contact and talk to program staff. Asking for advice in practical or technical matters and a common small-talk enhances students' well-being, as well as hinders minor matters from growing into problems.

In the student services special effort is put in preparing the degrees and the diplomas with the tight schedule. The diplomas are handed out in the Graduation Ceremonies in the beginning of September before the students leave Finland.

The Thesis topic selection and working on the Thesis research are the most important matters for most of the students. TT pays a lot of attention in answering the thesis related questions both before and after students' arrival. The thesis related matters are discussed more closely in the chapters 5 and 6.

4 STUDIES AT AALTO

The SpaceMaster studies at Aalto consist of courses related to Robotics and Automation which as a topic is of great interest to the students. Part of the courses is common with all of the automation technology students while another part is customized to the SpaceMaster program. The basic courses of Finnish language and culture are to support students' integration into the Finnish society.

There are big differences in the students' academic backgrounds and technical skills. TS of the two customized courses need to pay attention to this. The course on embedded programmable systems as an introductory course gives essential hands-on tools for the rest of the courses. Basic course in robotics is customized in order to give a space related view on robotics. The seminar course closely connected to the thesis work is for supporting the beginning of the thesis writing.

5 THESIS TOPICS

A special attention is paid on selection of the thesis topic. The student chooses a topic together with PD and TT. It is important to consider the student's background, personal skills and interests when selecting a topic for the thesis. Connection to the on-going research activities in the department is desired. As a result the students are more committed to working on their thesis.

Research topics within the Department's research projects are preferred. This provides the best possibilities to guide the students and to monitor their progress. In some cases students have also done their research in foreign universities. This requires much commitment and remarkable skills from the student and closer attention to the topic. Often the requirements of foreign universities differ from the ones of Aalto University. This results in difficulties with the scheduling of the work and may undermine the quality of the research.

6 THESIS

The schedule for completing the thesis in seven months is demanding. The work starts in January, and the deadline for the final draft is in the end of July. The thesis is evaluated and graded in the end of August. In order to make this possible, a considerable amount of work is required from the staff as well.

6.1. Supervising

As the SpaceMaster programme aims towards a double degree, two thesis supervisors are assigned; PD from Aalto and another from LTU, Sweden. TT informs the supervisor at LTU about the selection of the topic and the progress of the thesis. The abstracts and progress reports of the thesis are delivered to both of the supervisors. Of course, some special arrangements are needed because of the distance between the students studying at Aalto and the supervisor at LTU. The supervisor at LTU attends all the presentations and reviews, either in person or with the help of the Internet. Though internet meetings have proved to be valuable and efficient tools in the remote supervision of the thesis, face-to-face meetings are still necessary. The aims is to meet at least once during the process and it is especially important that both supervisors are present at the final presentation.

6.2. Instruction

A thesis work instructor from TS is appointed for each student. That is, a teacher with the most experience on the research topic. The instructor follows the student's progress and reports to TT about any possible difficulties of delays. Sometimes two instructors may be appointed; one for technical issues and another for academic issues like work planning, writing and schedule. TT follows the student's progress throughout the thesis work, discusses the thesis with instructors and the students, and makes sure that the deadlines are met. As a result, challenges to the process can be detected faster, which makes it possible to react to them sooner.

After agreeing on the Thesis topic, the student prepares a short abstract in order to show that he has understood the topic correctly. A couple of weeks later an extended abstract with a work schedule is requested. This abstract is used to make sure that the student has formulated the research problem properly, and he understands the related challenges and has a realistic plan to finish both the research and the writing process. At this point the instructor can give the necessary advice to guide the research in the proper direction. The guiding continues until the thesis is completed.

6.3 Starting the thesis

In order to start the thesis research and writing effectively, and to support the writing process, a specific seminar course is arranged in the very beginning of the thesis work. In the seminar the students are expected to perform a state-of-the-art study on the Thesis topic and to write and present a twenty-page report on the results.

The literature search is supported by the Aalto library information specialist. The writing process is started with the help of an English teacher giving lessons on academic and scientific writing, writing flow, grammar and style considerations, plagiarism and other thesis related matters.

6.4 Thesis guidance and monitoring

The thesis research progress is followed with several reviews to guarantee proper contents and keeping on the schedule. Two abstracts are requested from the students during the first weeks of the research in order to help their instructors in guiding the work to proper direction. At this point also the English teacher gives feedback on the student's written language skills. The Seminar report in the third month shows how the student has understood the given problem, how he has managed to get into the research field, and how he is planning to solve the problem.

In the end of the seminar course in late March the student gives a seminar presentation on his findings, his understanding on the research field and its challenges. He presents a plan of the following activities on how to continue and finalize the Thesis project. At this point the instructors and supervisors may evaluate whether the student's understanding of the research problem, the related state-of-the-art and his work plan are sufficient for meeting the Thesis requirements, and the project deadlines. Corrective actions may be given immediately as there is still four months' time to finalize the thesis work.

The Mid-term review in May, two months after first review and five months after starting the research is critical. It demonstrates the gained progress, and indicates the work still to be done. At this point the supervisors and the instructors may evaluate the feasibility of the research contents, and the need to redirect the work for meeting the deadlines.

Finally, in early August the supervisors and the instructors evaluate the Thesis draft. At this point it is not possible to do much about the Thesis research itself, but the main emphasis is on presenting and discussing the results, the overall lay-out and similar style-related issues. In some occasions also the theoretical understanding and discussion have been deepened at this late moment. The student gets advice on finalizing his work before having it bound into hard covers. Sometimes, if the update requests have been of a significant nature, another draft review may be requested before the permission for binding the Thesis book is given.

7 SUMMARY

It is in the interest of the SpaceMaster Program and of the Aalto University to get students to complete the Master's degree within two years. The results of this case study are based on continuous observing instead of statistics. They show that sufficient resources, both material and human, are needed for supporting the students. With the specified schedule the students' efforts can be guided into the desirable direction. With proper motivation and guidance the desired graduation times can be achieved also within our existing University environment. Of course, there is no reason to underestimate the effect of students' own attitude in gaining the results.

Sufficient human resources are essential not only for keeping the program running but also for being able to react with the expected and unexpected matters without delay. The key persons' informal and team oriented attitude and continuous communicating with each other enable them to be aware of the things going on, and to take an active role when needed. The lower students per teacher relation than in other study programs, increases the quality of teaching and tutoring. The possibility for learning to know the students in person enhances individual tutoring and guiding both in the academic and in the practical matters. The material resources like the specially appointed study room enhance students' integration in the research community. It provides contacts with the researchers, offers opportunity to learn a goal oriented working attitude, and thus increases the students' study motivation.

The tight and specified schedule and knowing it since the arrival day enhances students' motivation and commitment to the studies. Several of the students already have their goal in a doctoral degree or in employment after master's degree. No complaints have been presented about the extremely tight schedule, not either about the plenty of deadlines. On the contrary, the implicit schedule removes uncertainty about what to do and when as the students get a clear view about how to complete their master's degree at Aalto, right after their arrival. They also look forward to the Graduation Ceremonies providing them the Diploma before leaving Finland which facilitates the job and PhD position searching right after the graduation.

The reasons for choosing Aalto for the second year are mainly academic with different aspects of Finland-related reasons like safety and pure environment, or with some personal reasons. The program built-in mobility provides the students with two different academic cultures before the arriving at Aalto, and the knowledge about moving into another country etc. The students' attitude shaped by the first study year is visible when they arrive at Aalto. Studying in a multicultural group has grown the group spirit, the extreme winter experience has taught them to survive with obstacles. They have readiness and ability to do most anything, especially in completing their degree.

7.1 Summary of the students

Yearly around 40 students start in the SpaceMaster program. During the five years 35 students have studied at Aalto, with 22 different nationalities. Altogether 30 of them succeeded in graduating in two years, the rest having justifiable reasons for the delay.

The information of the first five years' Aalto SpaceMaster students' placing after graduation is presented in the Table 1. The number of students remaining in Finland is significant, compared to the number of students placing in Europe and in the rest of the world.

TABLE 1. SpaceMaster student distribution .

Position	Number of students
Working in industry in Finland	4
PhD position in University in Finland	8
Working in industry in Europe	7
PhD position in University in Europe	5
Working in industry outside Europe	7
PhD position in University outside Europe	2
Still doing the Thesis	2
Total	35

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165 DIFFERING CONCEPTS OF BIOMEDICAL ENGINEERING EDUCATION

J. Jan[1]

1 Brno University of Technology, Brno, Czech Republic, jan@feec.vutbr.cz

ABSTRACT

As the importance of formulating well the wide professional area of biomedical engineering is growing, several international initiatives are aimed at defining main features of the teaching process and also of the qualification requirements to the graduates in biomedical engineering (BME), at BSc and MSc levels. Presently, the educational concept is based on the three-stage university teaching scheme (Bc, MSc, and exceptionally PhD) according to contemporary legislation of most European countries. Although it gradually turns out that this system has not only positive features, the discussed curricula of BME tuition comply with the separate two stages – BSc and MSc.

Biomedical engineering is a wide concept, touching many different aspects from the technological as well as from biomedical and health-care areas. As a single expert definitely cannot cover the whole range of different aspects of BME, professional specialisations have been established, as e.g. medical electronics, or IT and diagnostic support, and others. We shall concentrate to these two ones, where the electrical / electronic and computer technology education forms the technological background, while the BME multidisciplinarity must be reflected by a reasonable part of biomedical education. Advantages and disadvantages of differing concepts will be discussed from the perspective of the long-term experience at the Brno UT.

Keywords: clinical engineering, biomedical engineering, theoretical background, multidisciplinary balance.

1 INTRODUCTION

The biomedical engineering (BME) is so far not quite precisely defined area, although it becomes more and more important due to increasing introduction of modern complex technology into medicine and healthcare. International discussions are running on how to formulate the main features of different areas of BME and to define the requirements to the teaching process at the universities. Also, the required qualification features of the respective graduates, both at the BSc and MSc levels, are gradually becoming more obvious. There are several international initiatives aimed at finding such formulations and also promoting them into the legislation; on the European stage, the important initiative is the BIOMEDEA (see http://www.biomedea.org/), which has formulated its recommendations primarily in [1], [2] and also in other documents, resulting from several international conferences of experts in the field of BME education [4]. This initiative is based on the three-stage university teaching scheme (BSc, MSc, PhD) according to the Bologna declaration (1999), which most European countries included into their legislation.

Although it gradually turns out that this new scheme has not only positive features compared to the previous consistent scheme of five year MSc study, the present contribution on the BME tuition concepts is based on the separate two stages – BSc and MSc, and aims at showing how to provide the optimum results under this limitation. This paper thus deals with curricula in separate BSc and MSc studies while the doctoral study in the BME, as not needed for commonly considered clinical application areas, is not treated.

On the BME forum, discussions are also running about whether the three year BSc study is sufficient for clinical technicians at a basic level, or if the BSc study duration should be prolonged to four years in BME area, or even, if only the MSc level can provide the necessary theoretical and practical level of knowledge for the demanding job of a clinical engineer or a technologically oriented member of biomedical teams, both in routine medicine and research. Let only shortly mention this problem with the compromising stand-point that BSc level might be useful in cases of simple routine and supportive work, for which the teaching system must provide a corresponding sufficiently versatile training, while the more-responsible positions in health-care or biomedical research institutions mostly require at least the MSc graduates if not PhDs. The most generic definition of biomedical engineering encompasses many different areas that should be classified from the technological point of view, as the graduates are – in spite of the multidisciplinarity – still primarily technicians or engineers. Just to mention the most important orientations:

- medical electronics – electronic diagnostic and therapeutic instrumentation, biosignal analysis
- diagnostic imaging systems, image processing and analysis
- information technology in biomedicine (hospital information systems, picture archiving and communication systems, genetic and other databases etc.)
- artificial intelligence, diagnostic decision support systems, intelligent diagnostic and therapeutic equipment
- biomechanics, biomaterials, prosthetic and rehabilitation technology,
- biochemistry, analyses and automatic biochemical labs,, drug and waste management,
- clinical engineering – routine management and support of clinical technology, e.g. operating theatres, monitoring and intensive care units, automated laboratory equipment, incl. some patient care,
- etc. (the list cannot be closed due to fast development).

It is obvious that a single expert cannot cover the whole range or even a substantial part of it. Therefore, combinations of two or three of the mentioned areas form common specialisations, as medical electronics and imaging systems (probably the most common orientation), the IT including hospital information systems and diagnostic support, or biomaterials, biomechanics and prosthetics, etc. From now on, we shall concentrate our attention to the specialisation of medical electronics and instrumentation including the first two areas of the above ones, and the bioinformatical specialisation, encompassing the third and fourth areas. For both these specialisations, the electrical / electronic and computer technology tuition forms the technological background, and the graduates should be educated accordingly.

Although many of the below mentioned generic ideas apply to all BME specialisations, the experience of Brno University of Technology, which influences the conclusions of the paper, concerns primarily these two areas.

2 TWO BASIC CONCEPTS OF BME EDUCATION

The multidisciplinary area of BME is in principle formed by two basic components: technological sciences and human – primarily biological, medical and social/ethical – disciplines. Although compromising attitudes can be found as well, we can basically recognise two differing attitudes towards the ratio of both components:

The "classical" technologically based approach to BME that formulates a biomedical engineer as a perfect technologist in its specialisation (e.g. electronics, measurement and signal/data processing), who however is distinguished from a standard engineer by a reasonable medium level of biomedical knowledge as an extra addition to standard technological competence. The medical subjects should be taught by medical people, in order to present the material in the proper "non-technological" way, however it is still done in frame of the respective engineering education. This biomedical knowledge is primarily aimed at the ability of students and graduates to communicate with medical staff, which also includes understanding the differing way of thinking of the medical people and their specific language; on the other hand, a detailed medical knowledge or paramedical training is not required. One of the advantages of this approach is a good mathematically theoretical and technological (system-oriented) background of the graduates that enables them to become valued members of biomedical (but also other) research teams and/or to solve non-standard technically complex and demanding problems. Another advantage is a wide choice of possible technological jobs for the graduates, including even industrial or other non-medical areas as e.g. communications, thus providing a better social security in case that the health care area becomes saturated.

The "modern" interdisciplinary approach to BME (often taught in cooperation of two universities – technological and human oriented) is distinguished by a higher level of biomedical and social knowledge, offered mostly at medical faculties, with a limited rather moderate technological background. The more in-depth biomedical education enables then the graduates to treat patients under or even without supervision of medical staff, and they are also expected to be capable of performing some paramedical staff tasks; this has been formulated already by BIOMEDEA documents and is nowadays required for the occupation of the clinical engineer by legislation in some countries, including the Czech republic. This extra capability is naturally limiting the technological background that can be taught, primarily in the theoretical part, and it also requires restricting the technological teaching only to the biomedical area applications. Obviously, the graduates can only be employed in biomedical, namely health-care area where they have the advantage of being relatively well medically educated, while – on the other hand – their applicability in medical field in cases of technologically or theoretically more demanding tasks, or even in jobs outside of medicine, is limited. In this type of education, the managerial abilities are stressed so that the graduates may serve primarily as middle-level managers of hospital technology and as the technological servicing staff. Often, the centre of gravity of their technological education is in bioinformatics, enabling them to manage also the hospital information systems, genetic and other databases and computing equipment. This type of education is now socially highly appreciated, which is also reflected in high numbers of applicants to study (partly also thanks to absence of demanding courses on math, physics and other theory); on the other hand, the job choice for the graduates is limited to the health care area.

Both types of study are offered primarily by technical universities. It is interesting that while the "classical" curriculum seemed to be partly in decline during several last years, it is reappearing now again, clearly as it turns out that the more interdisciplinarily educated graduates of the "modern" type cannot cover theoretically more demanding positions, namely in research and in technical development. This is the reason, why Brno University of Technology maintains – after recent introduction of "modern" type study branch – both types of study in parallel. Even more pronounced is this tendency at the specialised Faculty of Biomedical Engineering, Czech University of Technology (Prague – Kladno), which was established several years ago with the clearly "modern" interdisciplinary orientation, fully complying to the law for health-care employees. Last year, this faculty introduced a new study branch of biomedical engineering of the classical type (thus not fulfilling the health-care law requirements), as a reaction to the demand from practice.

Also some medical faculties are now offering the BSc in biomedical engineering, which appears less proper. A technologist, even in the BME field, needs a long-term education in technologically oriented teaching environment with well equipped labs and workshops, including properly trained technical staff, and also the adequately oriented theoretical background to become a technically oriented expert, besides the partial tuition in medical areas.

A controversial issue discussed namely with connection to the modern type tuition is how the interdisciplinarists should be taught the math and generally science theory (physics, systems and signals, etc.) in the limited available time, still avoiding the recipe-based problem solving without deeper understanding of the problem substance; i.e. how to preserve the university-level approach. Based on experience, we prefer – particularly for interdisciplinary students of the modern type – simplified (as necessary) theory presentation, limited to basic concepts, mostly without extensive derivations, but still a consistent theoretical tuition giving a clear system of formulations, concepts and applicable results, leading to a good understanding of intrinsic relations thus preparing for solving even new so far not treated problems.

These considerations finally formulate the problem, what degree of interdisciplinarity at the cost of specialised technological expertise is reasonable. This problem is, of course, not limited to BME; contemporarily, there is a strong tendency towards multidisciplinarity generally, and young people are attracted to study branches offering overview on a wide and varied fields. In a sense, it corresponds to the complexity of modern world and is therefore often reasonable; on the other hand there is an obvious danger of superficiality. While it is gradually necessary to leave out many details earlier considered necessary (e.g. students of BME instrumentation do not need any more the detailed circuit theory or design of ICs, and may nowadays remain at the level of block design), a consistent theoretical background is necessary.

3 BME EDUCATION SYSTEM AT BRNO UNIVERSITY OF TECHNOLOGY

The classical well-established and consistent five-year BME study system leading to the engineering (MSc) degree was reformed when the two-stage study system (BSc – MSc) was generally accepted. This reform finally lead to formulating two independent branches of BME study [8] that are run in parallel: the "classical" branch of Biomedical and ecological engineering (BEI) study and the "modern" strongly interdisciplinary branch of Biomedical Technology and Bioinformatics (BTBio), a substantial part of which – about one third – is taught by the Medical Faculty of the Masaryk University Brno.

The "classical" BEI branch [6] has been expanded partly to the environmental area: besides preserving the good theoretical basis and the well established courses on medical instrumentation, modelling, biomedical concepts etc., it includes also concepts, technology and equipment used in ecology and environmentalism (as explained in greater detail in [5]). This rather unique approach is based on the idea that the interdisciplinary area of environmentalism is similar in concepts and approaches to the interdisciplinary biomedical engineering. Particularly, the instrumentation used in environment protection is often based on the same or similar physical principles and uses similar technology as in BME. Similar is also the necessity of understanding the experts from a non-technological world. In spite of this (limited) interdisciplinarity, this branch of study still represents a full-featured electronic engineering education, enabling the graduates to find jobs even outside the health-care or ecological area.

The modern strongly interdisciplinary BTBio branch [7] reflects a strong tendency in the contemporary society to combine education from several earlier separated areas, while also requires more specialised tuition oriented towards particular jobs. In case of BT Bio specialisation it means that the graduates are more deeply biomedically educated, at the cost of less deep backgrounds in technology. Conequently, they are capable of working in hospitals, clinics or other health-care institutions and may be even allowed to treat patients in specified respects. They should combine the capabilities of highly (though rather narrowly) qualified technicians with a kind of paramedical qualification provided by the Medical Faculty. although the students are primarily enroled at the University of Technology. Following a bachelor-degree study established at Brno UT in 2007, a master degree branch was founded in 2010; both at the Faculty of Electrical Engineering and Communication but in the specific frame of a separate study program not included in the classical electronic engineering. This new form of study enjoys a great interest among students and – on the difference to classical engineering of all kinds – the interest is more than twice higher than the admission capacity.

A comparison of the curricula of both parallel branches will be presented at the lecture, showing that both concepts are quite far from each other, so that their parallel existence is thus substantiated, and cannot substitute one another.

4 CONCLUDING REMARKS

There is a high social demand for both types of BME experts – those "classical" who are primarily technically oriented with only a necessary "communication" minimum of medical knowledge and experience, and others "modern" who are more broadly (interdisciplinarily) educated with a deeper background in biomedicine and less deep technological education. The so far experience shows, that there is a sufficient interest among applicants for study in both branches. Both differing concepts of the biomedical and/or clinical engineering tuition are thus needed, at the BSc and MSc levels (however typically, almost all BSc undergraduates in both branches continue to the MSc level). It is important that the type and way of study, as well as the determination for the job market are different in both branches. The Brno example seems to show that such a view is feasible and reasonable. The well distinguished curricula for both branches, each individually consistent, have been designed in forms attracting enough numbers of new students.

It is the intention of the author to contribute to and possibly also motivate a further discussion on this topic, the potential for which is definitely not exhausted. This particular conference may contribute to it from some different so far not treated aspects.

5 ACKNOWLEDGEMENTS

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166 NORTHANTS ENGINEERING TRAINING PARTNERSHIP (NETP), A MODEL FOR SUSTAINABLE, INDUSTRY - UNIVERSITY ENGAGEMENT

Daniel Bailey[1] & Jonathan Adams[2]

1 The University of Northampton, Northampton, United Kingdom, daniel.bailey@northampton.ac.uk
2 The University of Northampton, Northampton, United Kingdom, jonathan.adams@northampton.ac.uk

ABSTRACT

Twenty-three years ago the University of Northampton along with a number or local engineering companies including British Timkin, Cosworth, Cummins, Express Lifts and KAB Seating formed a partnership to provide industry experience for undergraduate students. The founding aim of the NETP was: "to create a pool of 'industry ready' Engineers to support the Northamptonshire area".

This paper will evaluate why the NETP has been sustainable and how it has developed to meet the changing needs of educators, employers and students. Particular areas of focus will be; how the NETP has input into skills and knowledge and course / curriculum development; how it has supported graduate recruitment, enterprise and professional skills development; and how the NETP has supported research and local economic development.

Keywords: Industry Engagement, Student Placements, Internships

Index of Terms

NETP – Northants Engineering Training Partnership
NVQ – National Vocational Qualification
STEM – Science Technology Engineering and Mathematics

1 INTRODUCTION

The NETP formed in 1989 as a Limited company. The founding Partners were the University of Northampton, British Timkin, Cosworth, Cummins, Express Lifts and KAB Seating. The companies recognised that recently qualified engineers had the relevant academic qualifications but lacked the necessary experience to be useful to industry from the point of employment. To address this the NETP was formed. The NETP's original mission was to;

"create a pool of 'industry ready' Engineers to support the Northamptonshire area".

The NETP set up a paid placement scheme, where by students would spend a year split between three differing companies, attending University a day per week to continue with the academic studies. In recent years the NETP has developed to meet the changing needs of both industry and HE. Changes have included the expansion in the level and range of methods of engagement with the University and other stakeholders, including; schools and colleges, local government and industry professional bodies. To reflect this wider remit new mission and vision statements were formulated.

Mission: To create a pool of industry ready engineers of the highest calibre and position the NETP as a unique example of good practice and collaboration between Academia and Industry adding value to all stakeholders.

Vision: Aspire to increase membership and diversity by providing a platform for full student placements, formal and informal networking, sharing of good practice and inspiring students and Partners alike.

NETP Objectives:

- To continue to work closely with our partner industries to keep pace with technology and constantly update the curriculum.
- To update student and staff skills to keep pace with industry needs.
- To facilitate students learning outcomes by providing the widest possible range of teaching aids, external and internal.
- To provide Industry talks, visits and opportunities for all students to experience the "real world".
- To provide students with the necessary skills to compete for any engineering post.
- To address the problem of Gender Imbalance within Engineering.
- To ensure networking and support systems for all partners
- To invest in the future of the Manufacturing Industry by providing students of the highest calibre.

1.1 The Partnership model

Each company involved in the Partnership is elected to the board and becomes a director of the NETP. All Partners have equal say in the decisions made by and direction of the Partnership. No preference is given to those representing larger companies amongst the Partners. Partners meet on a monthly basis at the University to discuss operational and strategic development matters. Currently there are 17 industry Partners based in and around Northamptonshire UK, see figure 1. They represent a diverse range of engineering specialism and company size.

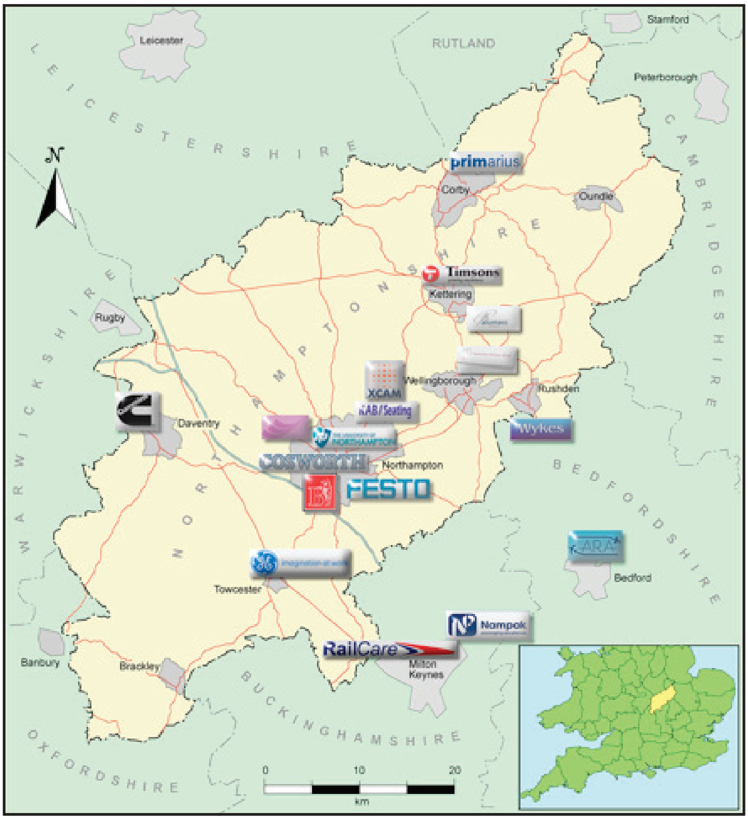

FIGURE 1. *NETP Partner Company locations.*

1.2 Membership

Companies can join as Full or Associate Partners. Full Partners are those who wish to get involved with all the Partnership activities, Associates are companies interested in supporting engineering education and development but are not in a position to employ a placement student. One of the reasons for the success and longevity of the Partnership is openness and flexibility in encouraging industry partners to engage irrespective of their ability to contribute.

2 METHODOLOGY

The information for this paper was gathered using a range of semi-structured interviews. Interviewees included NETP partner companies and undergraduate students. The groups were chosen to give a broad reflection of the NETP's operation, benefits and opportunities for development.

The interviews were recorded and transcribed. Analysis of this information was undertaken using the following qualitative data analysis methodology:

- data reduction; selecting, grouping and summarising the raw data;
- data display; developing a system to view the data in reduced form (e.g. matrices);
- conclusion drawing; extrapolating meaning from the reduced organised data in the form of regularities or patterns.

Miles and Hubermann (2002).

3 RESULTS

The results of the research were evaluated by the project team and used to create the data held within this paper. Following the interviews undertaken with the Partner companies and placement students key themes emerged, which are summarised below.

3.1 NETP in put to skills and knowledge

- Industry placement and internships: Provision of industry based paid placements is still one of the primary roles of the Partnership, in excess of 500 placement opportunities have been offered, and many beneficiaries have gained permanent employment within the placement company and the provision of these opportunities remains the primary reason which parties engage with the NETP. The development of Internships, which have recently been introduced, has been regarded as valuable addition to opportunities offered through the NETP, particularly to those students who cannot commit paid placement opportunity.

- Curriculum development: The NETP assisted with the design of the BSc Engineering programme and have had continued this input with the recent validation of the BEng and MEng and MSc engineering programmes. Curriculum development is a regular agenda item and Partners and the University see this input as essential to ensure that the content of the engineering courses remains current and fit for the needs of industry.

- Industry talks: A range of industry talks sponsored by the Partners have been held topics have included: project management, lean manufacturing, quality and environmental management systems, employability and many other engineering technical topics. These talks have been linked directly to course content to illustrate relevance.

- Industry tours: Sponsored by the Partners, these provide students with an opportunity to gain experience of a range of engineering businesses and activities, from complete manufacturing processes to aircraft research.

- Sponsored professional training: The NETP have developed a programme of industry based professional training for University undergraduate students, this has included insight into mechatronics, lean manufacturing, sustainability and innovation through research inspired by nature.

- NETP sponsored awards: Currently 2 annual awards are sponsored; The Alan Casey Award – Best industrial placement student and the Academic Award – Highest academic achievement. A new award for best 3rd year project has been sponsored from this year; this will include attendance to an international engineering trade show in Stuttgart, Germany. These provide additional recognition for the top performing students and inspire all to raise their game.

- Engineering society: New for 2012 the Engineering Department and the NETP have supported the creation of an Engineering Society. Partners have agreed to act as mentors to the society, particularly in the areas of innovation and entrepreneurial activities. Plans are in place to develop a social enterprise through this group.

3.2 NETP supporting graduate recruitment

Graduate recruitment and employability skills are supported and promoted in a variety of ways. Supporting this activity is core to the NETP mission. The following are a few examples of how the NETP supports graduate recruitment:

- Placement interview process:

The application for the industry placement is a 4 stage process and involves; evaluation of:

1. Academic performance including attendance and achievement
2. Technical achievement in the NVQ engineering skills course
3. Performance in the technical interview
4. Performance in the industry interview

Feedback is given on all stages of the process. This provides students with valuable information relating to their strengths and weaknesses. Partners provide advice and training to students via focused seminars and lectures aiming to improve areas of weakness.

- Annual Awards Evening: During this event students from all years and alumni alongside industry speakers, present to a diverse audience associated with the engineering sector and associated strategic partners. This provides a ‘real life’ opportunity for the students to demonstrate their knowledge and keys skills in a professional environment. Incoming second year students have to undertake a product analysis and present an innovative improvement. Each group is then quizzed by the NETP ‘Dragons’. Employers use this event as an opportunity to identify talented individuals.

- Engineering Industry week: This was developed for 2012 and was run in line with the UK National Science and Engineering Week. The NETP was a key sponsor of this week, which included a wide range of promotional activities to highlight opportunities for careers in Engineering and promote the strategic partnerships related to engineering within Northamptonshire. This very successful activity was awards highly commended in the Best Engineering Event 2012 by National Science and Engineering Week.

3.3 NETP supporting enterprise and professional skills development

- Mentoring Enterprise and entrepreneurship: Partners assist in advising and evaluating students’ academic activities relating to enterprise entrepreneurship. A current example involves mentoring students in the development of a new concept for a traditional product proposed by a ‘real’ customer. Working as part of a team second year students had to pitch a concept to the customer and a range of industry Partners and academics during Engineering Industry week. During this activity student had to keep a reflective personal logbook, this information was used to prepare an in depth evaluation of their performance in the task, relating the information back to key skills relating to improved employability. Feedback from both the Industry panel members and students was very positive and both parties saw great value in the activity.

3.4 NETP collaboration in research and innovation

- Commercialisation of University activities: NETP Partners have developed close links with the University NVision facility, which provides 3D and 4D data analysis and imagery; this has led to innovative development and commercial usage of the facility.

3.5 NETP collaboration in local economic development

- NETP student recruitment: NETP plays a key role in the improvement of the employment prospects of the engineering students and the research indicated that many students are attracted to the courses because of the strong industry links offered through the NETP. The founding aim of the NETP was to create employable engineers to support their businesses, this aim true today and the NETP Partners still employ a significant proportion the Department's graduates some of which are supported through their final year.

- Working with local strategic partners: The NETP works closely with local councils, FE colleges, Schools and professional bodies; Institute of Engineering Technology, British Institute of Non-Destructive Testing and Women in Science and Engineering and number of the Partners are also STEM ambassadors. These links have been very successful and are growing. The work received external recognition via winning the following awards:

National Science Week – Highly Commended – Best Engineering Event 2012
National Science Week – Winner of the Best Engineering Event Award 2011
Women in Science and Engineering - Winner of the Outreach Award 2010

Probably the most poignant accolade for the work undertaken via the NETP in this area was the feedback given by the beneficiaries, this is one typical comment: "Today was Awesome! I do not want to ever go home again. I want to live at the University forever" 8 year old Northamptonshire school child.

4 DISCUSSION

Why does this model work, what has enabled NETP sustainability?

The results above outlining the activities of the NETP have shown the continuing and broadening activities offered by the NETP.

Whish discussing the outputs and developments and evaluating why the Partners continued to offer support, if became clear that one of the primary reasons why the NETP continues to be successful is that it is a 'true' partnership each member has equal say in the decisions made by and future direction of the Partnership. There is a high degree of trust and commitment.

Partners share common goals, the main being supporting activities which further academic achievement to the benefit of students, business and economic growth. There is a high degree of ownership. Whilst the University is the host Partner, it has the same say in the decisions made as any other Partner. The operation of the Partnership, meeting once a month enables a responsive approach to change, keeps all engaged and builds strong relationships.

Success of the NETP continues, as there is a mutual benefit, all Partners gain in some way from taking part. Testament to the continued success of the NETP is seen by the number of UoN graduates employed within the Partner companies and is a significant factor in maintaining an employment rate estimated in excess of 90%, gaining employment within engineering fields.

5 CONCLUSION

The NETP provides clear benefits for all stakeholders involved with the Partnership. The Partnership continues to evolve and has introduced a number of key developments a key factor in the continued success of the Partnership. The format and inclusive approach to engagement with industry and the forward thinking of the Partnership has been the sustaining factor in the longevity and continued success of the NETP.

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167 ANALYSIS OF SIMULTANEOUS EEG/FMRI DATA – TEACHING OF DOCTORAL STUDENTS VIA RESEARCH

Martin Lamoš[1] & Jirí Jan[2]

1 Brno University of Technology, Brno, Czech Republic, lamos@feec.vutbr.cz
2 Brno University of Technology, Brno, Czech Republic, jan@feec.vutbr.cz

ABSTRACT

Electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) are two most common techniques used in neuroscience research. Currently, there is a growing interest in analyzing the measured data from both modalities simultaneously. The main motivation is to achieve the best temporal (by EEG) and spatial (by fMRI) resolution for the analyzed data. The contribution shows the concept of this interdisciplinary research forming a substantial part of doctoral study, enabling the student to work with realistic clinical data which were acquired during clinical experiments at the cooperating University Hospital and at the same time to utilize the deeply theoretical technological frame provided by the home University of Technology.

Keywords: Functional magnetic resonance imaging, Electroencephalography, Simultaneous EEG/fMRI analysis, Doctoral study, Interdisciplinary research.

1 INTRODUCTION

The paper describes, in a level of detail, a substantial part of the first author's doctoral study – the theoretically and technologically oriented interdisciplinary research performed in a close cooperation with the Neurological Clinic of the Brno University Hospital. In contrast to undergraduate and graduate studies, the curricula of which are commonly the subject of ICEE presentations, the doctoral study is highly individual and cannot be described by a typical curriculum. Particularly in case of an interdisciplinary dissertation, the choice of a suitable ("dissertible") theme and the realization of the research, crucially dependent on the availability of the biomedical measurements on patients, are demanding problems requiring a high degree of understanding by both involved parties – the technological and the medical faculties. The presented work describes such a running research and its first results, as an illustration of the respective approach to the doctoral study.

Neurologists are looking for connections between simultaneous electroencephalography (EEG) and functional magnetic resonance imaging (fMRI) data, trying to take advantages of both methods. Functional MRI utilizing the blood oxygenation level dependent (BOLD) effect as the indicator of local activity is a very useful technique to identify active brain regions [1]. The technique is based on repeated brain volume scanning by a MRI tomograph. The obtained 4D results have an excellent spatial resolution whereas a time resolution is significantly worse because the period of one brain volume scan is in the order of seconds. The EEG signal describes electrical activity of the brain measured by unpolarized electrodes and belongs to the group of stochastic signals in frequency band of about 0 – 50 Hz. The EEG has a relatively high time resolution in tens of ms, however the anatomical localization of the electrical activity is very inaccurate as the specific electrical sources, which are located deep in the brain and may have a very low signal-to-noise ratio are not accessible to measuring by the scalp approach [2].

Initial attempts in fusion of simultaneous measured EEG and fMRI, where asymmetric methods were used, are described in [3], [4] and [5]. Spectral information of the EEG is used for the construction of regressors in fMRI analysis. Resting-state datasets were analyzed and only α band of the EEG was in the spotlight. Methods for extraction of temporal patterns of EEG activity have also been developed [6]. These techniques are useful for the epileptic activity exploration.

This contribution shows basics of methods for working with the medical data on the interdisciplinary field of the simultaneous EEG/fMRI, where our doctoral students became involved.

2 DATA ACQUISITION

All of the data was obtained at St. Anne's University Hospital, Brno, 1st Department of Neurology, where simultaneous measuring system is located (to our knowledge the only in Czech Republic yet).

The used design of the specific experiment is the vision oddball task with distractor. There were three visual stimulus types, which were presented to the measured subject in random order. Each stimulus consisted of a yellow single capital letter imaged for 500 ms on the black background. Interstimulus interval varied from 4 to 6 seconds. A total of 336 stimuli consisted of targets (letter X, 15%), frequents (letter O, 70%) and distractors (letters other than X and O, 15%). Subjects were instructed to press the button whenever the target appeared, and not to respond to distractor or frequent [7].

Measuring of the fMRI data was performed on a 1.5 T Siemens Symphony® scanner equipped with Numaris 4 System (MRease). Functional images were acquired using gradient echo, echoplanar imaging sequence with TR time 1660 ms, matrix size 64×64×15 voxels per scan, slice thickness = 6 mm, FOV = 250×250 mm. The whole task was divided into four equal runs of 256 scans and 84 stimuli. Following the functional measurements, high-resolution 3D anatomical T1-weighted images were acquired (160 sagittal slices, resolution 256×256 pixels resampled to 512×512 pixels, TR=1700 ms) that served as a reference matrix for the functional imaging.

Simultaneously, the EEG recordings were acquired using BrainProducts® EEG MR compatible device. The EEG signal was obtained from 30 scalp electrodes (10/10 system), the EOG (electrooculogram) signal was obtained from electrode mounted under the right eye and the ECG signal from the subject's back. The latter signals were acquired in order to consider them as noise interfering with the analyzed EEG signal. The sampling frequency of all EEG channels, EOG and ECG signal was 5 kHz.

3 DATA PREPROCESSING

The SPM8 program (Functional Imaging Laboratory, Wellcome department of Imaging Neuroscience, Institute of Neurology at University College London, UK) running under MATLAB® R2009b was used for image data preprocessing. Functional scans were spatially aligned to the first scan of the first run by rotation and translation. The whole fMRI dataset was then registered to the reference anatomical image. Additional spatial normalization to the standard stereotactic space MNI (Montreal Neurological Institute template) is useful for a potential group analysis. After that, functional 3D images were resampled to the resolution of 3×3×3 mm and smoothed using Gaussian spatial filter with FWHM of 8 mm, which normalizes the distribution of the dataset. Finally, the time series of each voxel was temporally filtered to discard periods longer than 128 s.

EEG data were preprocessed using BrainVision 2.0 software (Brain Products®, GE) by which the EEG was corrected for gradient fields noise (caused by MR scanner) and pulse noise (heart action caused) artefacts. Eye blinking artefacts were corrected by removing the appropriate independent (ICA obtained) component from the data. Thereafter, the EEG dataset was converted to SPM file format and processed in SPM8 software. The electrocardiogram channel was removed at first, then the EEG channels were downsampled to 250 Hz and filtered with the bandpass IIR filter 1 – 40 Hz.

4 DATA ANALYSIS USING GENERAL LINEAR MODEL

After preprocessing, the functional data enter the statistical analysis aimed at fitting a general linear model (GLM). The calculation is based on linear regression analysis, which assumes that the BOLD signal is a linear combination of a constant element, multiples of model signals (regressors) and a vector of residues [1]

$$\boldsymbol{Y} = \boldsymbol{X\beta} + \boldsymbol{\varepsilon}, \quad (1)$$

where Y is the data matrix of all measured functional images (64×64 BOLD signals), X is the model matrix containing the model signals (regressors), β is parameter (weight) matrix that has to be estimated by least-squares error (LSE) minimization and ε is the error matrix containing a residual variability in the data (the error for each voxel). With respect to over-determination of the equation, the LSE evaluation of β is given by [1]

$$\boldsymbol{\beta} = (\boldsymbol{X}^T\boldsymbol{X})^{-1}\boldsymbol{X}^T\boldsymbol{Y}. \quad (2)$$

After obtaining β parameters, the T-statistics is used for thresholding thus providing the visualized brain activity maps. T values are calculated according [1]

$$\boldsymbol{T} \approx \frac{\boldsymbol{c}^T\boldsymbol{\beta}}{\boldsymbol{\sigma}} \quad (3)$$

where σ is the variance of ε and cT is the transposed contrast vector (i.e. a given control vector that defines which results will be displayed based on the selected model signal).

Regressors in a typical fMRI analysis comprise the prior or independently derived information about motion artefacts and the stimulation function (if the experiment design includes stimulation). In order to enable to joint fMRI/EEG analysis, we extend the number of model signals (regressors) in the GLM by adding the processed EEG data as regressors (Fig.1). There are two methods described in the next two subsections. The first one uses adjusted source neural electrical signal derived from the scalp EEG time courses as a regressor [6]. The second one works with predefined frequency bands of the scalp EEG data. Regressors are formed from mean short-term power spectra in this case [4].

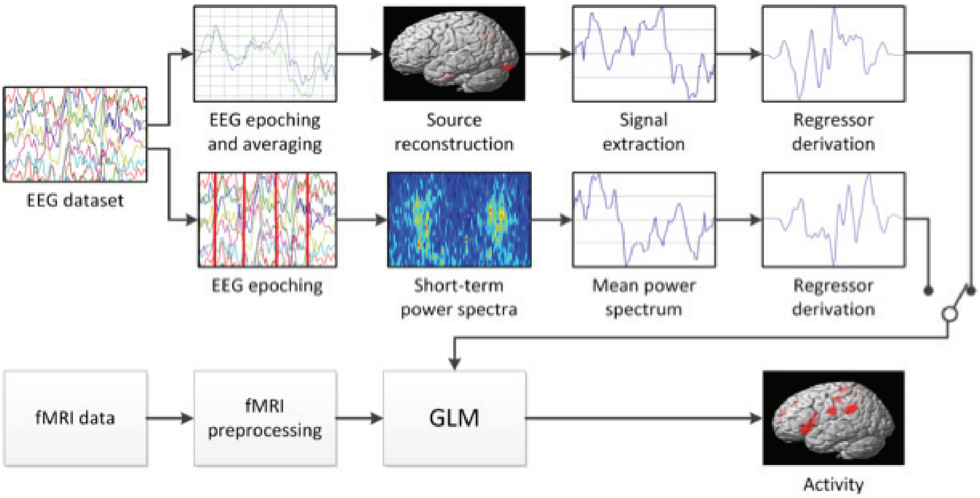

FIGURE 1. *Flowchart of the proposed techniques of the analysis.*

4.1 Reconstruction of the source neural electrical signal

The whole EEG dataset is epoched into time windows from -200 ms to 600 ms around stimulation marks (individually for all types of stimuli). Epochs belonging to the same stimulation type are averaged. During this step baseline in all epochs is corrected by subtracting the mean value of -200 ms – 0 ms window part in each epoch [8]. The source neural electrical signal from the region of interest (ROI) is obtained by 3D source reconstruction, which is divided into four consecutive steps. Source space modeling creates head meshes describing the boundaries of different head compartments based on the MNI template. EEG electrode positions are transformed to match the template head. Thereafter, derived spatial EEG data are coregistered into the structural MRI space. The next step is the forward computation, which refers to computing for each of dipoles on the cortical mesh the effect it would have on sensors. We use EEG Boundary Element Method (BEM) model that is included in SPM8. Finally, the inverse reconstruction problem is solved by Multiple Sparse Priors (MSP) algorithm to get the reconstructed signal from ROIs [9]. The source neural signal is adjusted into the model signal for fMRI statistical analysis using GLM. It includes resampling to the required length and convolution with the hemodynamic response function (HRF). The reason of using convolution with HRF is the synchronization between differently timed activities in EEG and BOLD signal.

4.2 Evaluation of the short-term power spectra

EEG signals from selected electrodes are separated from the whole EEG dataset. Each EEG signal is divided into as many sections in time as there are the acquired fMRI images. Each section of EEG signal corresponds to the acquisition time TR of one scan. There is also a possibility for increasing the time resolution when every single section is composed from the weighted sum of the appropriate part of the EEG signal and the previous and the next part each in length of the TR/2 time. The frequency spectrum is calculated for each section using the discrete Fourier transform (DFT) [10]

$$DFT\{f_{n,a,m}\} = \left\{F_{k,a,m} = \sum_{n=0}^{N-1} f_{n,a,m} e^{-jkn\frac{2\pi}{N}}\right\} \tag{4}$$

where a is index of an electrode, m is index of EEG section, fn,a,m is a section of EEG signal, k is index of spectral lines in the frequency range < 0 , fsampling > and N is length in samples of the EEG section. Spectral lines which lie outside of the interval of interest are then reset to 0 for each required frequency band individually. One power value is estimated for each fMRI scan in each frequency band. Absolute powers are calculated like a sum of power spectral lines of the chosen band [10]

$$P_{a,b,m} = \sum_{n=0}^{N-1} \left|F_{k,a,b,m}\right|^2 \tag{5}$$

where b is index of the frequency band. Relative powers are evaluated as the filtered absolute powers divided by absolute power Pa,m of non-filtered section of EEG signal

$$\delta P_{a,b,m} = \frac{P_{a,b,m}}{P_{a,m}} \tag{6}$$

Signals (time series) formed of these powers (absolute or relative) are convolved with HRF and the mean of power is evaluated for each frequency band across input electrodes. The last step in determination of regressors is normalization of the power values [11]. These vectors form regressors containing spectral information of EEG.

4.3 Cortical activities computation

Preprocessed fMRI data and regressors, which are derived using one of the above-mentioned methods, enter into the GLM. Brain activity maps are obtained with help of techniques described at the beginning of section 4.

5 RESULTS

After the fMRI analysis using GLM encompassing the regressor assembled from the source neural electrical signal, more precise localization of active areas were obtained (Fig.2). It seems to be very useful for seeking areas of epileptogenic tissue. The source neural electrical signal has to be selected based on potential epileptogenic phenomena in the scalp EEG data. These phenomena are chosen according to neurologist's experience.

In the second case where regressors of spectral powers were used in fMRI/EEG analysis by GLM we derived relative powers from 2 EEG signals from 2 occipital electrodes (O1 and O2) for α band (8-12 Hz). O1 and O2 were chosen because visual stimuli were used and the visual cortex is placed on the occipital part of the brain. The 1st-level statistics was calculated for each measured person. The 2nd-level statistics was set then for the group analysis estimation of the negative correlation (activity in cortical areas was higher when predefined frequency band power decreased) between α band power of EEG and fMRI time series. 2nd-level statistics was evaluated like one sample t-tests. Activity of the α band was estimated as statistically significant on the left part of the frontal hemisphere (Fig.3).

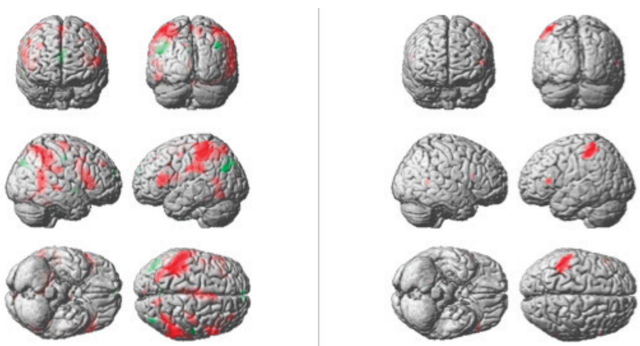

FIGURE 2. *Positive (red) and negative (green) activations (as a result of the two-tailed T test) obtained after GLM analysis with (right) / without (left) adjusted source neural electrical signal as a regressor. Saturation corresponds to the significance of the thresholded T value, significance level p < 0.001.*

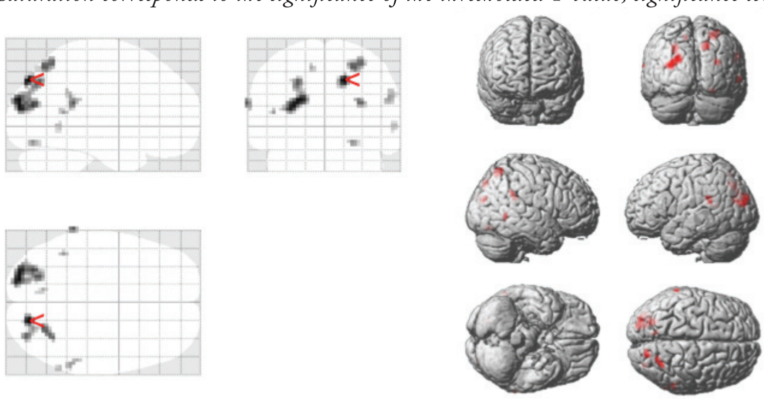

FIGURE 3. *Activity of the EEG α band negative correlation with BOLD signal obtained after GLM analysis using relative spectral power regressor (significance level p < 0.001 uncorrected). Maximal activity is marked by red arrow on MNI coordinates [18, -79, 43] MNI.*

6 CONCLUSION

We demonstrate techniques for enhancing the analysis of the joint EEG/fMRI data set by including the EEG data processing into the fMRI statistical analysis based on GLM.

The first method uses EEG source localization for obtaining the source neural electrical signal from the ROI. The signal is edited via time-domain processing to the regressor form and is applied in the statistical analysis of functional image data. More precise localization of active areas is reached. The method is very useful when the source signal is obtained from the scalp EEG dataset where epileptogenic courses are registered. There is a very high possibility for identification of epileptogenic centers in this case.

The second method using regressors formed as time series of a short-term spectral band power confirmed existence of a negative correlation between α band of the EEG signal and BOLD signal for studies with oddball stimulation. Present publications [3], [4] and [5] work with resting state (without stimulation) data only.

Datasets were processed with help of existing software environment like MATLAB, SPM toolbox and BrainVision. However, a substantial part of software tools had to be developed, because some procedures are insufficient or missing in the existing applications.

In the future work we would like to continue in extracting more relevant data, which are used for the regressor assembling. It is expected to provide a useful tool, enabling simultaneous EEG and fMRI data analysis from different points of view. However, it is desirable to find still another approach where the time resolution will not be decreased. One of the ways could be using the EEG information in the evaluation process of fMRI aiming at the effective connectivity analysis.

The contribution demonstrates the concept of interdisciplinary research as a substantial part of doctoral study in the area of biomedical engineering, enabling the student to work with realistic clinical data and at the same time to utilize the firm theoretical technological frame. There was also an opportunity to involve several master degree students in the marginal parts of the project under guidance of doctoral students, which turned out profitable for them as a practice in professional guiding of younger collaborators. The graduate students also gained largely in terms of working on interesting problems and learning basics of research work methodology – a good experience for potential future doctoral students.

7 ACKNOWLEDGEMENTS

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168 NETWORKED SMART EDUCATIONAL DEVICES FOR ONLINE LABORATORIES

Hamadou Saliah-Hassane[1], Maarouf Saad[2] & Willie K. Ofosu [3]

1 TELUQ – University of Quebec and LICEF Research Center saliah@teluq.ca
2 École de Technologie Supérieure Maarouf.Saad@etsmtl.ca
3 Pennsylvania State University, Wilkes-Barre Campus, wko1@psu.edu

ABSTRACT

The advantages of online labs, which also include remote laboratories for educational institutions and research and industry, are well known. Their use leads us to propose, either in addition or instead, the concept of home laboratories or labs at home. In terms of infrastructure and equipment, the miniaturization of measuring instruments and the new standards make it possible to easily network with speed and provide a high quality of service while making their acquisition costs no longer prohibitive. On the online learning environment side, the new situation is that Cloud computing enable educational institutions to use open source, or the social web or software to create a network of learners employing their equipment available at their homes. It also makes the network accessible to other classmates and instructors from anywhere. In this article we present the concept of laboratories at home as we see it in the light of Cloud computing era, the existing norms and standards to take into account as well as to develop to achieve educational goals required for electrical engineering laboratories with what we can be referred to as Networked Smart Educational Devices.

1 INTRODUCTION

Educational institutions are constantly looking for ways to improve learning, making learning a very dynamic process. This has served societies well in that learning no longer takes place in a classroom, but rather the classroom has been extended to include the environment. In this sense, many aspects of learning are no longer localized. Field trips have become an integral component of learning. Another form of learning that has added to the learning process is distance education.

In discussing distance education, one must consider the different disciplines and how well each lends itself to distance education. Disciplines that are laboratory intensive such as the sciences and engineering have included online laboratories including remote laboratories [1]-[3] in the distance learning format. One of the conditions that contribute to constraint in this endeavour is safety. In this case it is always advisable to have supervisor who is an expert in the field of study present during the laboratory exercise to guide the laboratory work. Another constraint is the cost of equipment which for some disciplines is very high considering the type of work being done.

The information age has advanced education beyond expectation as a result of the computer being used as a tool, no different from using a ruler as a tool to measure distances. The multitasking ability of the computer has proved to be invaluable in this case. The ability to network the computer in any one of the topologies of local area network (LAN), metropolitan area network (MAN), or wide area network (WAN) have added to the advantages the computer provides the education environment. To add to this is the wireless connectivity that extends the facility to areas where wired connectivity can be problematic. These developments provide the requirements that will support labs at home [4], and for the same reasons Cloud computing [5] have added to the emphasis.

To push the bounds even further in achieving what might have been impossible a few years ago is the introduction of Smart Technologies [6] to the education environment. Smart technologies have provided devices that have improved the interactive engagement in the education process. The products include smart interactive whiteboard, Smart projectors, Smart collaborative software, Smart wireless slate, and Smart interactive podium, to name a few. Two operative words among this list are interactive and collaborative. These two words are clear indication of activities being conducted in real time and in team atmosphere. This is not to say that individuals cannot do their work on their own. The intention however is to enable sharing of ideas, which is a useful process in the education environment.

Putting all the above together makes available an education environment that will support learning at all levels from K-12 to university, and will also support researchers in their work.

As stated above, education is no longer localized. And to make it even more accessible to the learner, a team of researchers have introduced the Lab@Home [4] concept that brings the education process to the learner in his own environment, his/her home. The versatility of Lab@Home is it combines all the current developments and brings it to the learner, or researcher, at his or her home through cloud computing. Cloud computing is not a new technology, and has been discussed in an effort to bridge the digital divide in secondary education [7]. The strength of Lab@Home is its ability to combine virtual instrumentation in its range of applications. This puts at the individual or the team's disposal access to expensive equipment that the individual, or a less endowed institution may not be able to purchase.

2 THE LAB@HOME ENVIRONMENT

Lab@Home is made up with distributed user stations that connect through their local networks into a 'Cloud'. Laboratory devices, if available can be connected to the computer. The users have the ability to collaborate through the network. A networked conferencing environment can be set up through the Cloud to create a platform named BigBlueButton for the participants. BigBlueButton was the result of a project on an open source software [1]. It does not as yet have the capability to store and share data. The software is adapted and deployed on a Virtual PC which acts as a server, and allows each invited participant to connect and initiate a self or collaborative laboratory session. The functionalities that are implemented are based on a project [8] on real time distributed learning environment. The functionalities are as follows.

1. Application Sharing: this enables a learner to share his/her entire desktop or windows on his/her networked computer, including connected laboratory user interfaces,
2. White board: Used for annotation and drawing during a synchronous session,

3. Private or Public Chat Rooms,
4. Audio and Video Conferencing: Participants can share their webcam with others,
5. Uploading and Presenting Documents.

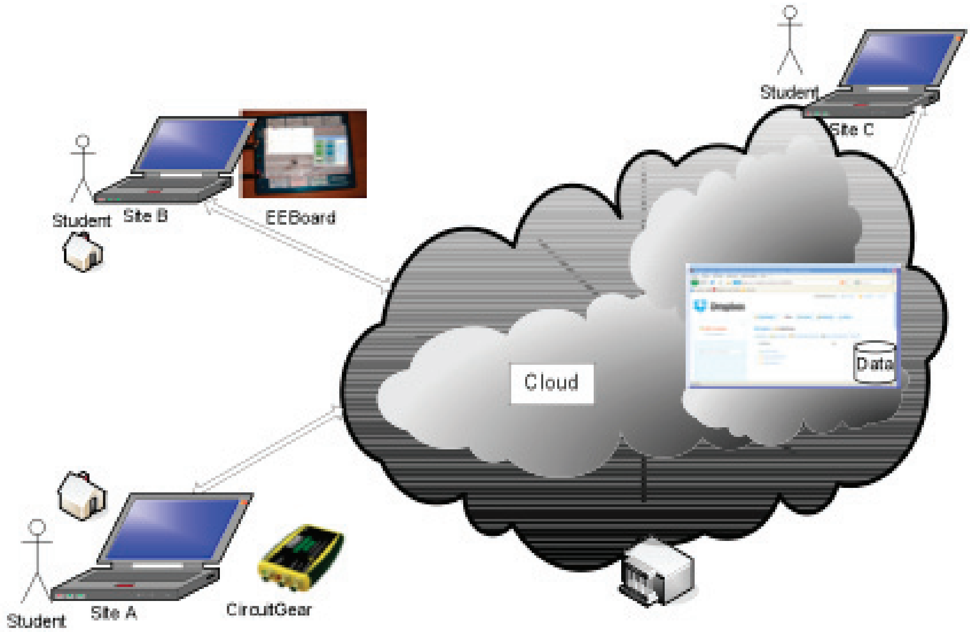

FIGURE 1. *Lab@Home Gobal Architecture.*

To date, BigBlueButton has been used in combination with an open source software [9], a social web software add-on that allows participants of a given learning activity to store and share files and documents through computer networks.

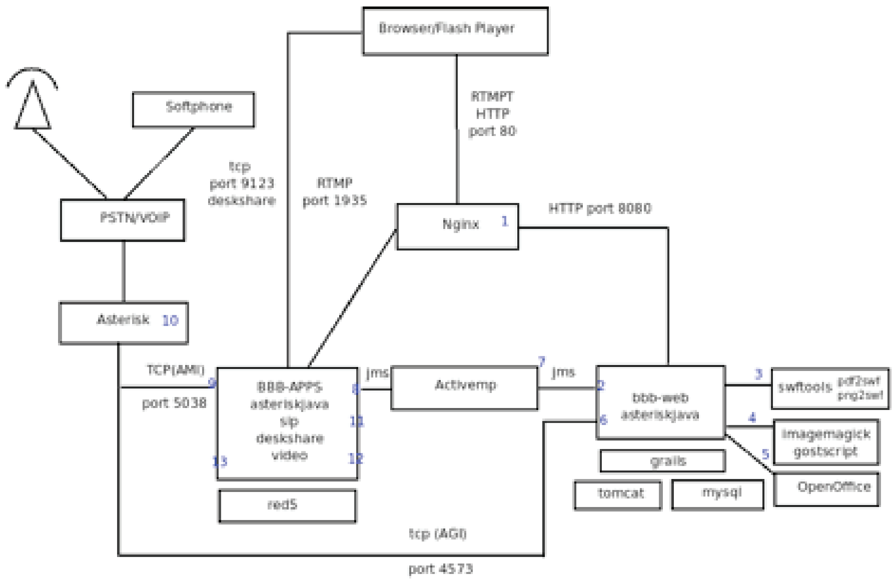

FIGURE 2. *Architecture of BigBlueButton [10].*

BigBlueBotton is a collaborative conferencing system deployed on the VMware virtual machine which is described in [10].

TABLE 1. Description of the Architecture of BigBlueButton.

1	*Nginx (engine x) proxies bbb-web bbb-apps to support RTMPT (RTMP Tunneling) server out the bbb-client*
2	*Grails application that handles creating conference and scheduling. Also,handles login and logout when joining the conference.*
3	*Responsible for converting PDF prensentation slides to Flash*
4	*Responsible for converting PDF presentagion slides to Flash in case SWFTools is not able to convert.Also, generates the thunbnails.*
5	*Responsible for converting .doc .ppt & .xls files to PDF presentation slides.*
6	*The AGI (Asterisk Gateway Interface) queries the database to determine if the dialed in voice conference number is valid or not .*
7	*Message conduit between bbb-web and bbb-apps*
8	*Red5 application responsible for synchronizing all the participants in the conference.*
9	*The AMI (Asterisk Management Interface).Listen for user events (joined/left,mute/unmute, talk) and issues commands (mute/unmute, kick user) to Asterisk.*
10	*Voice conference server .*

3 LAB@HOME AND DISTANCE LEARNING

Distance has always been a constraint to learning in that life conditions make it difficult for some people to relocate to cities where education is accessible. The same argument can be advanced for some people in their professional and business activities where they are unable to get time off to attend classes at university and college campuses. Distance education and online courses have proved to be a necessity for such people to upgrade themselves.

With the advent of modern technologies in recent times, this area in education is being put to very efficient use, and in developing nations this mode of learning can be views as critical. This is in light of the fact that many major cities are over populated and decentralizing the learning activities will help redistribution of the population, and needless to say, it will afford more people the opportunity of contributing the the development of the nation.

The foregoing makes Lab@Home an appropriate technology in that it makes available the facility needed for learning at any time and in any place including the premises of some business enterprise, and the home. Through the virtual environment, participants can access sophisticated hence expensive equipment that they would otherwise be denied. Lab@home makes possible the experiential learning that is an essential component of education in the sciences and engineering. As shown in Figure 1, multiple participants can engage in a research project and share data. This environment also makes it possible to hold a laboratory session for which the instructor can be connected to the students through the Cloud. By use of Smart Technology devices [6], the instructor can engage the students in an interactive session. E-learning (electronic learning) can be effectively employed in cases where the students have a research project that requires them to access information from libraries or research laboratories. The social networking tools that can be accessed by connectivity through the Cloud will provide access to free resources that will enhance the teaching and learning process for all participants. The positive learning environment that is created will promote learning in various modes such as being a participant in a team or on one's own with assistance from the instructor.

Many third world nations are actively seeking development, and they all realize that educating their youth is one of the approaches to achieve this goal. Among the numerous advantages that can be gained are improved economies. As they become active participants in the world market, not only will they be consumers, but they can also process their raw materials to finished products which will fetch better prices at the market. For this to happen, industries can seek the assistance of universities and colleges to help train their employees. Industries in these nations can take advantage of Lab@Home to connect to universities and colleges for this purpose. Through such partnerships, they can build a highly skilled technical manpower after the fashion of many developed nations, notably the US. This has been the result of such partnership between college and industry that has led to commercial knowledge transfer to industry [11].

All this can happen at some cost which the individual cannot bear, and in many instances, smaller companies may not be able to absorb. It is however a situation that those governments can include in their plans for development, and assist their universities and colleges, industries, and their people to achieve. In the African environment such cooperation will be a major step that will help in making the African nations equal partners in the world economy.

4 CONCLUSION

Advances in technology have led to improvements in education, and such advances have been in part as a result of innovative ideas generated at universities and colleges. One such innovation is the Lab@Home platform that enables participants to connect through the computer cloud for educational pursuits. Lab@Home takes advantage of smart educational devices to provide users with current technologies to further their education. It enables users to work either in teams or on individual basis, and to consult with an instructor as the need arises. It can be used in environments in both developed and developing nations. It provides a positive educational environment that assists both the learner and the instructor in the learning process.

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171 LEARNING STRATEGIC MANAGEMENT SKILLS WITH BUSINESS SIMULATION GAME

Markus Forstén[1], Osmo Eerola[2], Ari Putkonen[3] & Tristan Robinet[4]

1 Turku University of Applied Sciences, Turku, Finland, markus.forsten@turkuamk.fi
2 Turku University of Applied Sciences, Turku, Finland, osmo.eerola@turkuamk.fi
3 Turku University of Applied Sciences, Turku, Finland, ari.putkonen@turkuamk.fi
4 Pierre-Mendès-France University, Grenoble, France, tristan-robinet@voila.fr

ABSTRACT

Strategic planning is seen as proactive management of setting a company's goals further ahead and preparing its functions for future challenges. At Turku University of Applied Sciences (TUAS), special attention is paid to students' business skills needed in today's working life environment. The contents of strategic management courses are based on scientific literature on strategic management theories. However, strategic management techniques are challenging to practice and learn in a university setting without the context of a living business environment. This paper discusses a concept according to which strategic planning and management skills can be fostered with the help of collaborative business simulation gaming. Selected tools of strategic management were integrated with an existing business simulation game (ProDesim) and tested in a simulation session, where students applied their theoretical knowledge in a simulated business environment. Based on the feedback collected, it can be anticipated that simulation gaming offers students the possibility for a quicker adaptation of strategic management techniques, which in turn can lead to a more comprehensive understanding of strategic management.

Keywords: Strategic Management, Business Simulation, Edugaming, Learning.

1 INTRODUCTION

1.1 Significance of Strategic Management Learning

By classic definition, strategy means the way to win a war, or in the best case, to achieve the goals without war [1]. Every professional engineer needs a basic understanding of strategic management, since successful leading and effective working in any modern organisation is impossible without a clear mission statement, a formulated vision, and operative management structures and processes. In today's private business sector, strategic thinking and management is more important than ever, as product and service life cycles get shorter, competition increases, and new technological innovations may disrupt entire businesses in short time periods. Also, Kunc and Bhandari [1] have studied that rehearsing of strategic management skills can be a powerful tool to avoid reactive strategic behaviour in real life crises.

1.2 Strategic Management Learning in TUAS

Most bachelor level courses are intended to offer the basic skills and competences needed to successfully start a professional career in serving the subject discipline as a junior engineer. Business management, entrepreneurship, sales and marketing, as well as other similar subjects are often included only as optional courses, or introduced on a basic level during the engineering studies leaving the more thorough learning later.

Topics in strategic management are included in several courses in the Technology Competence Management graduate study programme, which is intended for engineers (B.Sc.) with a few years of work experience and a clear need to widen their skills base towards business management. Such courses are Competence management, From innovation to products, Managing and developing business processes, and especially the Technology strategy course, which first introduces the basic concepts and historical development of general strategic management, and then concentrates on issues like technology forecasting, technology foresight, technology road mapping, and R&D management. The course emphasises "true strategic thinking" of both ends of the value chain, i.e., technologies as facilitators and customers as business drivers, instead of operational excellence, which concentrates on organisational efficiency. A business simulation game has been used in the master studies as an optional course, and it has been well adopted by the students.

1.3 Applied business simulation game

In this study, we applied a business simulation designed for work communities and teaching organisations called ProDesim. It simulates the operations of a product development company for a five-year period. During that time, the participants develop multiple products according to their interpretation of the current market situation. The participants of the simulation learn and get feedback about the economical results of their investments in product development, market dynamics, project management, personnel management, scheduling and issues concerning interaction and expertise levels of the group [3].

The objective of ProDesim is to demonstrate the varied challenges of company decision making in order to bring forth the whole to which the participants' own work is connected. Understanding systemic structures and key interrelationships is essential in recognising the factors influencing the behaviour of the system over time [4]. In-depth knowledge of the system as a whole facilitates improving participants' own work and identifying possible complications within the product development process [5]. By understanding the dynamic relations between roles and tasks, they are able to better appreciate the significance of different phases of development and the origins of varied product development expenses.

Eight roles and the corresponding simulation tasks have been created to simulate the responsibilities in small and medium sized (SME) business environments. The roles have been generated to cover the obligations concerning the decision making in a development or design intensive company. The Managing Director makes the final decisions concerning new products and actions to improve the company's well-being. In addition, he/she also has to keep a constant eye on the financial situation. The Marketing Manager is the one fixing the marketing budget and product prices. He/she is also responsible for studying the market situation in terms of market share, for example. The Personnel Manager deals with all operations linked to Human Resources Management (HRM): hiring, training and other matters concerning the company's employees. The Product Manager takes care of product orders and after-sales activities. He/she is also responsible for one the most crucial aspects in the game, which is managing the product stocks and making the decision whether or not to terminate the production of a certain product. The Testing Manager performs tests (on durability and consumer approval) in order to improve the product's quality and customer satisfaction. The Project Manager sets all the characteristics in the product project. For instance, he/she controls the number of employees working on the project, the project's duration, the budget and the targeted product margin. The Design Manager is the one who sets the features of the product as well as makes consumer satisfaction enquiries regarding the features. The R&D Manager executes research on the product's features for upcoming projects; this provides the possibility to reduce the time spent to create a product and improve its quality.

2 IMPLEMENTATION OF STRATEGIC MANAGEMENT TOOLS IN THE PRODESIM SIMULATION GAME

To help the game participants capture a better overall vision of the simulated company, certain strategic tools were selected for use in a gaming session. Thus, the participants' focus shifts more towards planning and strategic management during the game session. Additionally, the aim is to enhance the communicational aspect within the team through planning their actions and improve their awareness about the decisions made.

2.1 Selected Strategic Management Tools

The tools were selected to support participants' strategic management in the simulation game tasks. The core element chosen was the 5Ps theory. This notion relates to a wide definition of what strategic management is and introduces its users to the pre-planning, realisation, and re-adaptation processes of a strategy. Five Ps (Plan, Position, Perspective, Ploy, Pattern) will conduct users all along the strategic management. Plan will point out the importance of preparing the action environment in order to avoid mistakes and reduce threats. Position can be used to emphasise the firm's location in a competitive market. Perspective deals with the necessity to identify opportunities in this precise environment. Ploy relates more to the objective of overcoming competitors; that is to say, reflecting on how to take advantage of competitors. Pattern brings forth the importance of taking a look at the results of the actual strategy in order to modify it (if necessary) and mainly to ensure its efficiency for the future (anticipating the future). [6]

Another chosen element that enhances the 5P's and helps to steer the company towards the chosen strategy is the BCG Matrix (or growth-share matrix) [7]. This tool is important in the way that it facilitates product management and helps players to forecast the position of their product on the market. Thus it will be easier for them to understand the products' environment and identify their profitability for the firm. The lifecycle curve [8] of a product helps players to assess products' attractiveness on a market and to anticipate their saturation and avoid mistakes in stock quantity. The notion of competitive advantage [9] assists in developing a product.

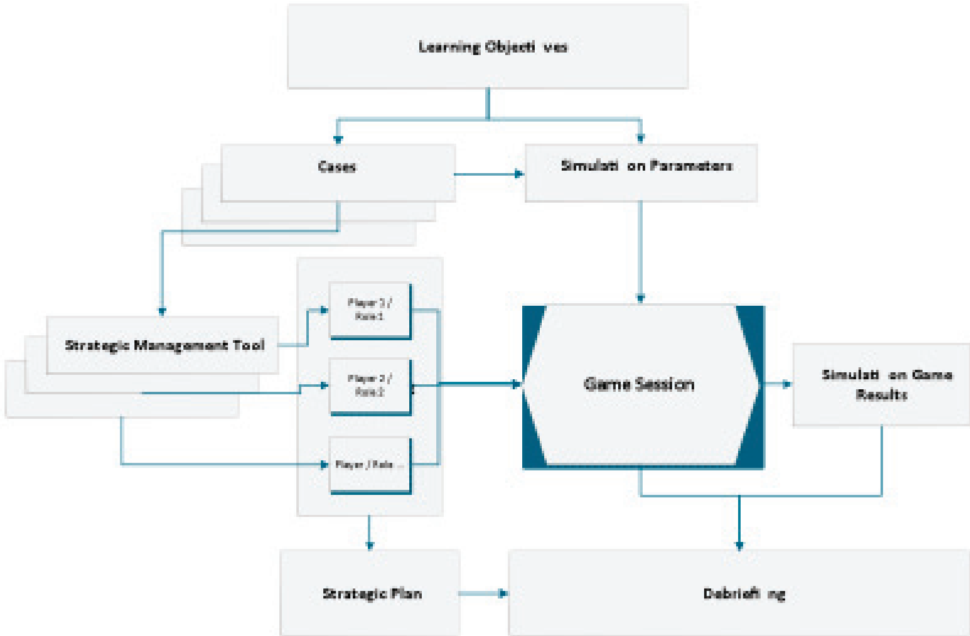

FIGURE 1. *The strategic management tools' implementation in a simulation game session.*

The implementation of the strategic management tools is described in Figure 1. The tools are meant to be applied on the various, pre-defined business cases. All the cases are designed to correlate with the simulation model parameters and the players' roles. It is noted that the interaction between system components is more important than if the components would function separately [5]. A business case includes problems that relate to complex challenges during the simulation game session. This leads to a situation that will generate discussion and opinion sharing between the team. The more problems are created, the better the chance of getting the needed commitment that makes for a good class room discussion [10]. The aim is to create an environment where the participants collaborate in a joint effort and recognise the importance of the thinking the system as a whole. When a player's prior knowledge and know-how is utilised in simulation problem solving and decision making situations, it generates collaborative action and emotional flow to the simulation [11].

2.2 Reactive vs. Proactive decision making

To create the strategic plan, some forms need to be filled in by the players. These forms are designed to give a sense of the strategic aspect during the simulation. The Overall plan is to be filled in before the actual gaming session starts. This is the main guideline in which all information regarding the strategic choices of the team is written.
Once put together, the forms and strategic tools help players to build their own strategy and understand their actions (i.e. think, then do).

Different tools and supportive forms need to be linked to the roles. Table 1 shows the strategic plans and the assigned roles. The "Contents of the Plan" relate to the strategic elements to build the firm's plan and the "Tasks" are their representation in the game.

TABLE 1. *Strategic plan features and tasks corresponding to each simulation game role.*

Strategic plans and assigned roles	Contents of the plan	Tasks
Overall Plan ***(road book)*** *- Managing Director*	1 - Answer the following initial questions *Where are we now?* *Where do we want to go?* *How will we get there?* 2 - Analyse the environment 3 - Set main objectives 4 - Sum up the strategy before implementing	- Fill in the financial form - Analyse scenario modifications - Analyse new needs after modifications - Set new objectives - Make sure that the strategy is well respected in the firm
Product Plan *- Product Manager* *- Marketing Manager*	1 - Fix product number 2 - Cost leadership or differentiation and define product´s aim: profit or sales oriented 3 - Define which product becomes a star, dog, cash cow… (BCG shaping) 4 - Orders' quantity for each product 5 - Fix expenses in advertising 6 - Set price strategy (e.g. penetration)	- Set orders and price depending on the product strategy - Adapt the strategy with new competitors (analyse competitors product and set the new product strategy) - Readapt product strategy depending on its results on the market - Choose to stop producing a product
- R&D Manager *- Project Manager*	1 - Set equivalent budgets 2 - R&D timing 3 - Launch month of products 4 - Production length 5 - Fix prices	- Fix features - Adapt new products' launches with the lifecycle curve - Respect product time line and long term vision - Adapt features' research & development
Quality Plan *- Testing Manager* *- Design Manager*	1 - Design quality plan 2 - Define quality factors (for each product)	- Adapt product characteristics with chosen features - Set product quality when producing - Design new product
HR Plan *- Personnel Manager*	1 - Set hiring employees policy (how many and when) 2 - Choose where to place employees in the company 3 - Fix training budget and evaluate needed productivity	- Hire/fire employees according to the strategy - Reallocate employees - Take actions on productivity and training

3 RESULTS OF THE STUDY

Firstly, the game facilitators found that with the overall plan and the strategic management tools added in the game, it became easier to start playing. Using the tools gave the impression that the simulation session worked more smoothly than in the sessions where the tools were not used. The typical stage of incomprehension in the beginning of the game, when players seem to be a little bit disoriented, was avoided. Moreover, quite often in the beginning of the gaming session, players encounter a few problems in making their first decisions due to the lack of shared knowledge on the simulated company. This naturally demands more preparing time before the session.

Secondly, the strategic management tools helped to facilitate communication in the team. This is an important point since enhancing group communication skills is one of the fundamental objectives of ProDesim. The tools and forms helped to improve this aspect especially during the planning stage of the session. This is also the moment when participants might still have difficulties in communicating effectively, especially when they are not familiar with each other. The fact that they are now asked to prepare their strategy in advance encourages them to participate actively from the beginning and improve their communication as the team.

Table 2 shows the simulation game participants' perception of the seven statements indicating the advantages of the implemented strategic tools. The distribution and average of the answers are both presented. The responses indicate that the tools help to understand the company position (average 4.4) and participants felt that they were able to act on the plan rather than react on the simulation session (average 4.5). On the other hand, not everyone in the team had a clear vision how to reach the given objectives (average 3.5). As a summary, it can be stated that the participants think that the strategic tools utilised helped them in several ways during the session.

TABLE 2. Simulation game session participants' (N=8) satisfaction on the strategic management layout.

Statement	1	2	3	4	5	Total	Average
Understanding the firm's position	0	0	0	5	3	8	4.4
Understanding the environment	0	0	2	4	2	8	4.0
Following a guideline	0	0	2	5	1	8	3.9
Acting more than reacting	0	0	0	4	4	8	4.5
Clear objectives	0	0	2	3	3	8	4.1
Clear vision to reach the given objectives	0	0	2	3	2	8	3.5
Improve team's communication	0	0	3	2	3	8	4
Total	0	0	11	26	18	56	4.1

4 DISCUSSION

Strategic management is a challenging subject to learn and practice during university studies, because they typically lack a living business environment. This study presents a concept how the strategic planning and management skills can be enhanced by a business simulation game.

The main finding is that strategic tools may not be enough in helping players in constantly preparing and anticipating their decisions. With the strategic management tools, the simulation game session participants were both reactive and proactive depending on the stage of the game. Reacting to an unknown environment can be seen as natural, if not instinctive, behaviour. It has also been noted that you can set main course for the company with strategic planning, but more considerate navigation must be done during the journey [12],[13]. Especially when the company faces a crisis in their operating environment, the resulting behaviour can quite often be described as a route of "hunch and hope" [1]. In a simulation gaming session, however, it is seen as a positive part of the attraction and reinforces participants' engagement. The game facilitator is able to utilise this in the session debriefing to reach the learning objectives.

This study was our first attempt to integrate strategic management tools with a business simulation game. The number of subjects was very limited and therefore the conclusions are preliminary only. However, we hope that these minor findings encourage additional studies on this emerging field of edugaming in order to find new methods of developing students' strategic business thinking already during their studies. A simulation game gives its participants a lot of tasks and assignments to achieve in a fairly short period of time, but with strategic planning this load may lighten and can be transferred to more rational decision making.

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173 THE FUTURE OF ENGINEERING EDUCATION?

Ville Taajamaa[1] & Kati Vilonen[2]

1 University of Turku, Department of Information Technology, ville.taajamaa@utu.fi
2 Aalto University, School of Chemical Technology, kati.vilonen@aalto.fi

ABSTRACT

This paper is outlining the future development trends of engineering education in Finland. It is based on a background study about future engineering education and working life requirements, a survey about current state of engineering education from the students' perspective in two different universities, and on theme interviews in one of the universities. The objective was to find out how well CDIO approach [1] would fit to serve the education development needs of the universities involved. The universities in question were University of Turku [UTU] which is the second largest multidisciplinary university in Finland and the largest one with engineering education and Aalto University [Aalto] that was founded in 2010 by merging three universities together: Helsinki University of Technology, Helsinki School of Economics, and the University of Art and Design in Helsinki.

It looks very important for both universities studied in this paper to do systematic curriculum development. UTU's case it will be the implementation of CDIO Introduction to Engineering and Capstone project courses and continue working with the CDIO platform. Also Aalto has decided to use CDIO as a mind-set in the development of bachelor programs in engineering, although there is not that strong commitment than in UTU.

Keywords: Engineering Education, Multidisciplinary Engineering Education, CDIO, Future of Engineering

1 INTRODUCTION – ENGINEERING EDUCATION IN FINLAND

Based on the research of Korhonen-Yrjänheikki and Mielityinen engineering students in Finland get an excellent problem solving capacity based on in depth knowledge of technology and science [2,3]. Meanwhile interpersonal, communication, teamwork, business and entrepreneurial skills are not emphasized enough [2,3]. This means that engineering students need to be taught both new skills as well as the teaching and learning methods themselves need to be improved [1,4,5,6,7]. The teaching and learning environments as well as applied teaching methods are important also for study motivation and for retention of students in engineering curriculum [8].

Schiavone 2007 [7] states that engineering students should be taught in:

- Time management techniques
- Effective note taking
- Coping with different teaching styles
- Getting help from professors and other sources

- Making effective use of class time–lectures, laboratories, and seminars
- Effective problem solving skills
- Writing clear, concise, and logical solutions to problems
- Collaborative learning–group or team work
- Effective study skills
- Being effective when preparing for and writing examinations
- Communication skills–written and oral
- Creative thinking

A study on future working life requirements made by Academic Engineers and Architects in Finland - TEK 2009 [4] states that "future engineers need to be better prepared for collaborative learning and shared expertise". It further states that content wise the engineering studies in Finland are in good order but more emphasis needs to be put into curricula development and developing the teaching and assessment methods. The problem solving skills have been the key strength for Finnish engineers [4]. In the future, however, the problems will be more and more complex and multidisciplinary approach in a complex problem setting is needed [1,6]. The challenge in the Finnish science university system is that in the science universities the main interest has been scientific research [5]. This means that although the academic tradition emphasises the transfer of the latest research to teaching the reality has been that the pedagogic development has not been systematic, in research intensive universities research is also usually more appreciated than teaching [9]. Secondly the student–teacher ratio is too big to offer possibility for individual guidance and discussion and there are still very little clear objectives for the improvement of the quality of teaching [5].

1.1 Case UTU

Engineering education in Turku comprises of Information Technology [IT] and Biotechnology. Especially in IT, there is an on-going development process "Engineer meets Human" where the goal is to integrate the key strengths of the multidisciplinary university into the engineering education. This is done by introducing thematic multidisciplinary profiles from UTU´s excellence areas to the curricula of the engineering education. Integration of multidisciplinary thinking and courses into the engineering studies is done in both bachelors as well as in master's level.

In UTU the development of engineering education started in June 2011. The change process received positive support from the top management of the university and from the management and faculty of the IT–department. In August-September 2011 it was realized that CDIO might prove as a useful platform and a holistic way of thinking for the development process. The change process towards CDIO structure and constructive alignment in planning and teaching started with the forming of five change teams.

The first team "Strategic Thematic Profiles" searched for thematic key strength profiles from the UTU excellence areas. The idea was to integrate multidisciplinary thematic strength areas to the undergraduate studies. This way student will get a wider perspective about the working life requirements for the future engineers as they are already exposed to different disciplines, values and ways of thinking and working in their undergraduate studies. Second team "IT

Core Competencies" started with the creation of intended learning outcomes [ILO] for degree, module and course level. The idea is that in the future there is no need to define the degree and module level ILO´s each year. Even course level ILO´s are although concretely defined still abstract enough so that the teacher can focus on content development instead of redefining the structures each year. Third team "CDIO" focused on CDIO requirements and international collaboration. In CDIO team the courses "Introduction to Engineering" and "Capstone project" were structured and planned along with the needed learning space development. Another important issue for team three was to plan the training for the faculty. Team four "Working Life Readiness" discussed and planned how and in which courses the integration of personal and interpersonal skills take place. This was done in close collaboration with the team number three "CDIO". Finally team number five "Study Plan" integrated the work of all the other teams into a new syllabus. All the teams consisted of faculty and student representatives. The five teams consisted of 21 different persons from the faculty and student representatives. Five persons from the faculty were in more than one team.

1.2 Case Aalto CHEM

In Aalto University, having together six different schools of technology, business, art and design, this study concentrates in the School of Chemical technology [Aalto CHEM]. Nowadays there are three separate degree programs, chemical technology, materials science and bioproduct technology in Aalto CHEM. All bachelor level degree programs in Aalto University are under the development process. New improved programs with wider disciplinary content including also working life relevant skills and attitudes will start in the autumn 2013. CDIO approach has given a useful framework for this curriculum development work. Although many small features of CDIO have already implemented in the individual courses of the old curriculum, these is still needed lot of improvements in planning and executing teaching in order to be able to add all required learning outcomes of future working life into the new curriculum.

2 RESEARCH METHODS

Our research question was if the CDIO approach could be used as a development tool in the universities in question. In UTU the research was covering primarily IT and partly Biotechnology. In Aalto the research was covering the School of Chemical technology. To gather empirical data about the learning objectives of current degree programs a survey was done [10] for students in UTU and Aalto CHEM consisting of CDIO syllabus 2.0 [11]. The goal was to get an idea where the two Universities stand in comparison to the Syllabus 2.0 i.e. how well the students feel that the issues in CDIO syllabus 2.0 are embedded in the degree programs. There were all together 33 answers, 20 from UTU and 13 from Aalto.

In addition to the survey a present state analysis was done in UTU during January and February 2012 through thematic semi structured interviews [Attachment1]. The interviews consisted of themes such as: "Background information", "Fundamentals of Engineering Education in UTU", "Curricula & Course Structure", "Collaboration inside the University" and "Pedagogics and Learning Development". There were all together 20 faculty, 10 students, 3 alumni, and 2 industry interviews.

3 RESULTS OF THE SURVEY

The survey was looking out the learning outcomes of the CDIO Syllabus 2.0 [11]. Although we received only 33 answers we decided to make a quick and dirty analysis of the results in terms of the Expected Proficiency Levels [EPL] [1].

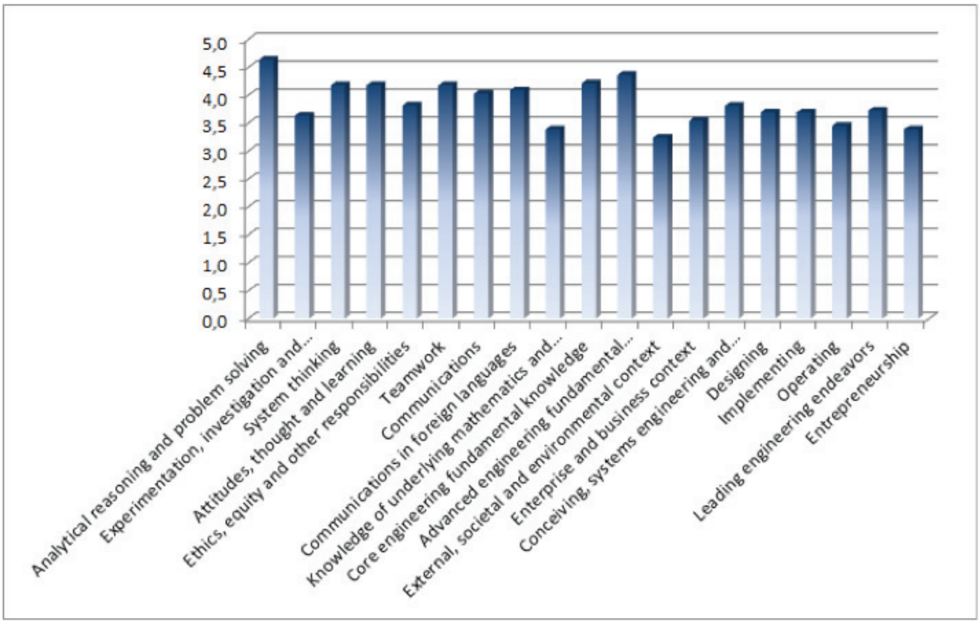

FIGURE 1. *The average values of Expected Proficiency Levels from the student survey.*

As seen in Figure 1 students in UTU and Aalto think very similarly compared to the results presented from the students at Queen´s University Belfast [QUB] and at MIT [1 p.71]. When comparing the EPL to the actual learning experience in all of the other parts of syllabus except in "Survey of Print and Electronic Literature" the EPL was higher than the learning experience. In this case the EPL for "Experimentation, investigation and knowledge discovery" was 3,64 and the learning experience was 3,73. Only in the "Knowledge of underlying mathematics and sciences" -section the EPL and the learning experiences were somewhat aligned. The EPL was 4,21 and the learning experience in for example "mathematics" was 3,58. In especially sections such as Designing" and "Implementing" the EPL was much higher than the learning experience. This can be partly explained by the fact that the majority of the students have studied from 1 to 3 years and in current curriculum they have not yet reached those more project related learning outcomes in their early study years. This would further support the idea of implementing CDIO hence in CDIO the Conceive-Design-Implement cycle is taught to the students already in early phase of their studies.

3.1 Case UTU

The results from the survey and especially from the semi structured theme interviews [10] showed that there is a clear consensus that something has to be done in order to further develop the engineering education in UTU. What, how and with what resources were the main questions that rose from the interviews. The need for development was especially in curricula, course structures, and also in teaching and assessment methods. In many cases the multidisciplinary collaboration inside and outside the university was seen problematic. There is a clear interest towards it but lack of time or other resources and conservative attitudes hinder the collaboration. Creating a culture where multidisciplinary collaboration is the modus operandi was seen to take time, need a lot of concrete action, and it should be beneficial to all parties involved.

The actual content i.e. what is being taught was perceived to be in good order. The idea of paradigm change "from teaching to creating learning experiences" was well received and understood among faculty and to some extent among students as well. In students case, however, the change "from teaching to learning" awoke questions such as "what does this actually mean", "how is it going to be done", "does it mean more work for us". One possible explanation for this is that the faculty was already somewhat exposed to CDIO and to the constructive way of perceiving teaching and learning. The majority of students, however, had no idea of CDIO. All of the interviewed students found it important that the students were taking part in the change process.

3.2 Case Aalto CHEM

In the case Aalto CHEM it is also clear that intended learning objectives of the current degree programs require development. Especially in the areas of personal and professional skills, teamwork and communication interpersonal skills and conceiving-designing-implementing-operating students saw those learning objectives more important than they experienced they were so far learned in their current degree. When analysing the new learning outcomes designed for coming bachelor program in Aalto CHEM, it looks that most of those partly missing outcomes in current curriculum are more emphasized already in a general level of curriculum.

4 NEXT STEPS FOR DEVELOPMENT

4.1 Case Aalto CHEM

In a new combined bachelor program, starting in autumn 2013 in the School of Chemical Technology there is need to improve the both linking the knowledge, skills and attitudes in course content and teaching and learning methods used in the courses of first study year. At the same time there are requirements to engage the freshmen into their own field of study and also offer some courses in the level of whole Aalto University. In those common Aalto courses the goal is to link topics between engineering, art and design, and business already in the beginning of studies. The framework of introductory courses in CDIO curriculum model offers useful practices to be implemented both in those Aalto level first year courses as well as first year courses on school level. Previous experiences from trials of different teaching and learning methods, such as project work and experimentation, have shown the potential of them in improving the students understanding and applying knowledge already in early phase of studies.

4.2 Case UTU

In UTU the next steps will be to introduce an “Introduction to Engineering” –course [ITE] to first year students and to launch the first Capstone-projects for master level students. Both courses will start in fall 2012. In ITE the idea is to go through the engineering process: Conceive, Design and Implement in cycles individually as well as in teams. The platform for ITE will be the Lego Mindstorm-robots [12]. The course will be divided into two 7 week periods. In the first period the students will learn theory and techniques that are needed in period two. This will be done through hands-on working with Lego robots. In the second period they will have tasks and competitions with the robots. The skill level and the problem solving level will be set higher after each week to keep the motivation of the students high. The aim of this Introduction to Engineering -course is aligned with the CDIO Standard 4 “An Introductory course that provides the framework for engineering practice in product, process, and system building, and introduces essential personal and interpersonal skills” [1]. In addition to this it will facilitate learning in the disciplinary knowledge of IT.

The master level students will do a multidisciplinary Capstone –project with the students from other faculties. In the first phase the thematic profiles are from the areas of “Health Technology”, “Game and Educational Technology” and “Global Information Society”. Global Information Society –profile will first focus on Chinese culture, language, economics, business and politics. The structure of the Capstone project is aligned to the CDIO Capstone project. The projects will have students also from other than engineering disciplines. It will have several stakeholders and it is done to a real-life project with a complex and multidisciplinary assignment setting. The intended learning outcomes are similar to other Capstone projects in other universities [13] but with an emphasis in multidisciplinary understanding and capability to communicate to different stakeholders. Example of this is the ILO: “communicate engineering in a multidisciplinary environment to different stakeholders – via discussions, in writing and in presentations”. The first Capstone-project will be launched as a multidisciplinary project with students coming from different disciplines inside UTU. The Capstone project will be all together 30 ECTS [15 + 15 ECTS]. Typically it will contain 15 ECTS for the project and 15 ECTS from the individually selected courses that support the actual project. The Capstone intended learning outcomes are as follows:

After the course the participant is expected to be able to:

1) Analyse technical problems in a systems view perspective
2) Analyse and solve technical problems which are incompletely stated and develop iterative solutions strategies subject to multiple constraints
3) Develop strategies for systematic choice and use of available engineering methods and tools, and solutions approach while understanding the socio-economic impact.
4) Make estimations and appreciate their value and limitations to guide the design and implementation processes and due the value judgments
5) Make decisions based on incrementally acquired knowledge

6) Pursue own ideas and realize/implement them practically as member of the project team
7) Assess quality of own work and work by others
8) Work in a true project setting that effectively utilizes available resources and applies good timely project management practices
9) Explain mechanisms and processes behind progress and difficulties in projects
10) Communicate engineering in a multidisciplinary environment to different stakeholders – via discussions, in writing and in presentations

The basis for the Capstone intended learning outcomes came from the ILOs of the KTH [Kungliga Tekniska Högskolan, Stockholm, Sweden] "capstone design course" [13]. The ILO´s in that course are:

1. Analyse technical problems in a systems view
2. Handle technical problems which are incompletely stated and subject to multiple constraints
3. Develop strategies for systematic choice and use of available engineering methods and tools
4. Make estimations and appreciate their value and limitations
5. Make decisions based on acquired knowledge
6. Pursue own ideas and realise them practically
7. Assess quality of own work and work by others
8. Work in a true project setting that effectively utilises available resources
9. Explain mechanisms behind progress and difficulties in projects
10. Communicate engineering – orally, in writing and graphically

In UTU´s case the biggest changes compared to the capstone design course ILO´s at KTH [13] are the ILO of functioning in a multidisciplinary environment and communicating to different stakeholders inside and outside the team. This is best presented in ILO number 10. The capstone projects will utilize the key strengths of UTU: Wellbeing and Health Technology, Game and Educational Technology and Global Information Society.

5 DISCUSSION AND CONCLUSIONS

In UTU the biggest challenge is the integration of the benefits brought by the multidisciplinary university into the engineering education. The actual syllabus, study plan and creation of intended learning outcomes have gone as it should. "Engineer meets Human" -slogan can, however, only be actualized if all the involved stakeholders work towards the objective. The change process has to happen both in top management and in the faculty level, and not to forget the students. The idea of changing the paradigm of education "from teaching to learning" is well received among faculty. Next step is to create pragmatic and concrete steps to implement new ways of teaching and assessing. This means that emphasis has to be put into the pedagogic development of the faculty. In this process the Introduction to Engineering and the first Capstone project courses will play a big role.

In Aalto CHEM the biggest challenge in the renovation process of a new bachelor program is probably the successful combination of all intended learning objectives in new courses in a way which directs deep learning and applying skills for students, supporting their motivation at the same time. This will require teacher level cooperation and planning both the whole curriculum as an entity and also individual courses with their more specific learning outcomes and teaching methods. In order to be succeeded this process requires also strong support from the management. CDIO will offer instructions and inspiration for that process in a form of standards and syllabus but the attitude to do the change must come from faculty.

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174 INTRODUCTION OF STUDENT INITIATED AND THEMED MULTI-STUDENT PROJECTS

Roelof van Silfhout[1], Ian Cotton[2], Bruce Grieve[3], Alexander Lanzon[4], Alasdair Renfrew[5] & Andrew Gibson[6]

1 School of Electrical and Electronic Engineering, The University of Manchester, M13 9PL Manchester, United Kingdom, r.vansilfhout@manchester.ac.uk
2 School of Electrical and Electronic Engineering, The University of Manchester, M13 9PL Manchester, United Kingdom, ian.cotton@manchester.ac.uk
3 School of Electrical and Electronic Engineering, The University of Manchester, M13 9PL Manchester, United Kingdom, bruce.grieve@manchester.ac.uk
4 School of Electrical and Electronic Engineering, The University of Manchester, M13 9PL Manchester, United Kingdom, alexander.lanzon@manchester.ac.uk
5 School of Electrical and Electronic Engineering, The University of Manchester, M13 9PL Manchester, United Kingdom, alasdair.renfrew@manchester.ac.uk
6 School of Electrical and Electronic Engineering, The University of Manchester, M13 9PL Manchester, United Kingdom, andrew.gibson@manchester.ac.uk

ABSTRACT

We present the background to a change in the delivery and supervision of third year projects for students majoring in electrical and electronic engineering at Manchester University and an evaluation of our experience with this new system. One of the recent changes in the delivery of projects has been to task a smaller number of staff dedicated to the supervision of third year projects. Balancing the increased demand on staff supervising third year individual projects with increasing the quality of supervision has prompted us to change the delivery mode of third year projects. One of the main initiatives is to group individual projects under a 'theme' that will offer places for approximately six to ten students working under supervision of an academic member of staff usually with assistance of a research group member. Although students still perform an individual piece of work they benefit from joint training on (for example) software tools, the use of equipment, key techniques and higher levels of peer support.

We will reflect on the organization of the themed projects, project allocation, their delivery, supervision and support structures that we have put in place. An evaluation of demands on staff time, student experience and preparation overhead will also be presented.

Keywords: Individual project, project supervision, practical work.

1 INTRODUCTION

The final year of the B.Eng. Honours degree in engineering in the United Kingdom requires students to complete and pass an individual project that carries 30 credits out of a total of 120 [1,2]. The third year project is the only course module in which students perform a substantial, individual piece of work and allows them to 'shine their light' [3]. Traditionally, the delivery of this part of the curriculum is through allocation of a small set of students to an academic supervisor. The allocation process is initiated by publishing a list of project topics that supervisors offer and students are requested to select several topics to aid the allocation process. Once allocated students would nominally work for 300 hours on their project spread over two semesters with a final project report due before the summer exam period.

Delivery of this specific part of the undergraduate degree is particularly demanding in terms of supervision and second examiner duties when compared to a regular module. In the past most academic staff of the School were involved in the delivery of individual projects but this was no longer deemed an effective use of staff time. At School level it was decided to task a smaller subset of academic staff with the delivery of individual project whilst at the same time introducing methods of efficient delivery of this particular part of the curriculum. The introduction of themed projects was inspired by the realisation that the largest demand on the staff time was related by weekly supervision duties and introduction into the topic of research. Thus through joint introduction, training and project progress meetings significant savings would be possible. To aid with day-to-day support, research associates or students are available to help familiarise students with equipment and techniques.

Here we report on experiences with this new scheme that were collected by running three themed projects with about twenty students during academic year 2011/12. This new type of project ran alongside the standard projects and student initiated projects using exactly the same deliverables and marking schemes. To give an overview of the way projects are run, we start by describing the organisation of individual projects in terms of deliverables that students have to provide throughout their third year and how they are assessed. We will then discuss in detail how themed projects and student-initiated or 'bespoke' projects differ from the supervision of standard projects. We will conclude by summarising our experience and future plans.

2 PROJECT ORGANIZATION/DELIVERABLES

Figure 1 shows a flow diagram of the six deliverables that students have to provide. These deliverables are deliberately spread over both semesters to encourage students to work on their project continuously but also to include further elements of professional development (time scheduling, poster design, report writing, presentation skills). Four of these deliverables are marked; the final project report carries the largest weighting factor of 70% whereas the other three have an equal weighting of 10%. Apart from the presentation and question & answer session, all deliverables are electronically submitted to Blackboard, the university's web based e-learning tool. Two academic members of staff, the project supervisor and an independent examiner, mark four key deliverables using spreadsheet templates.

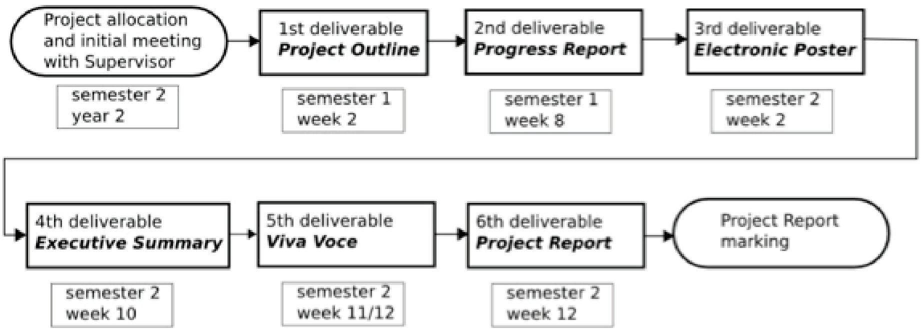

FIGURE 1. *Flow diagram of project deliverables.*

The templates organise the various items of assessment that feature textboxes for formative feedback and numeric marks (0-100%). Completed mark sheets with marks and comments are returned to students through Blackboard. The templates are made available to students as part of the project handbook. Before each deliverable, a briefing session is organised for the whole year to explain the specific requirements, give examples and to answer questions. Supporting documents and examples are disseminated through the Blackboard system.

The delivery of the third year project already starts in semester 2 of the second year of undergraduate studies when a presentation is made to students regarding project arrangements, type of projects and call for bespoke projects. A list of all standard and themed project titles and description is issued with a deadline at the end of semester 2 for returning a ranked ordered list to the project coordinator. To reduce staff overhead a web-based form is used where students enter their selections (see figure 2). Usually around 80% of students can be allocated their first choice and a small number of students enter into a second round of project selections because they cannot be allocated to any of their selections. If possible, the project coordinator will give students that opted for multiple type projects a choice before issuing the project allocation.

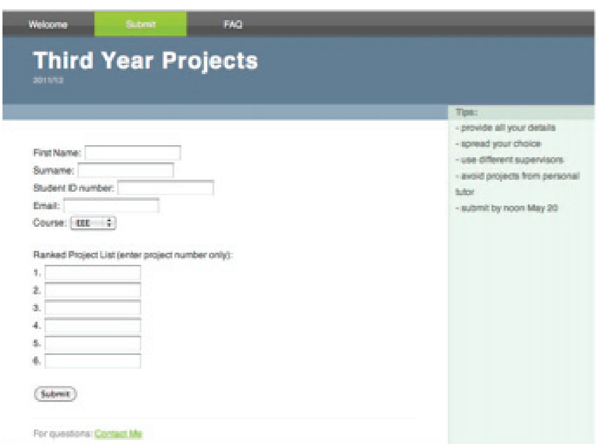

FIGURE 2. *Web based student project selection system.*

The first deliverable is the project outline (no more than 200 words) which is due two weeks into the first semester. The project outline is not marked. Instead it is used to inform the project coordinator that students have met their supervisor and that a project has been agreed upon. The topic of the project generally is the same as that allocated but can differ as long as supervisor and student agree on the new topic. The project coordinator also uses the project outline to allocate an independent examiner that is knowledgeable of the specific project area.

Eight weeks into the first semester the progress report is due. This report is intended to show that the student understands their project, that they can plan its execution, have considered their options (e.g. design routes, methods) and can provide a critical appraisal. The report (10 pages) will also contain (as an appendix) a health and safety risk assessment, a Gantt chart and project risk analysis/mitigation.

The third deliverable is a project poster that is submitted early in the second semester. The project poster is aimed at a 'non-specialist' audience and allows students to develop skills to communicate project impact, project aims, approach taken and progress to date using graphical design. The poster is marked with the largest contribution of the mark related to the visual appearance and quality of the poster in terms of explaining the project with a small contribution to the mark in terms of technical achievement. For many students it is the first time that they have engaged in making a professional poster and the School provides a briefing session showing examples of good practice.

At the end of the project we ask that students prepare an executive summary of their project in preparation of the viva voce. During the viva voce the student presents the project work to both supervisor and independent examiner and answers their questions. This fifth deliverable is jointly marked by the two members of staff and feedback is given to the student. The feedback includes suggestions of improvement to the executive summary. The student will revise the summary and use it as the abstract of the final project report, which is the sixth and final deliverable. The viva voce is a great opportunity for markers to acquaint themselves with the project outcomes in preparation for marking of the final report.

The final report is due at the end of the second semester and is limited to 50 pages. The marking of the final report consists of two different mark sheets, one for the supervisor and another one for the independent examiner. The only overlap of the two mark sheets are the sections of technical achievement and testing, analysis and conclusion. The independent examiner judges the quality of the report in terms of English, use of figures, clarity etc. whereas the supervisor is asked to mark project management, and ability to progress independently.

3 THEMED PROJECTS

During the academic year 2011/12 we started by offering three themed projects. Initially the number of students per theme was limited to seven in order not to load the supervisors with a larger number of students than their colleagues running 'standard' projects. The topics of the three themes were selected to align with the current research themes of the School: eAgri, Autonomous systems and Smart grids. The themed projects were advertised to the students using a briefing meeting with a short description of each topic of research and their impact. For the Smart grid theme, for example, the following description was used.

"In September / October 2011, a monitoring system will be installed in 11 substations of the University power system. The monitoring system that is deployed will measure the voltage and current passing into 16 low voltage distribution systems supplying University buildings. The availability of this unique power systems monitoring system provides extensive opportunities for smart grid projects. The monitoring system is based on the compact RIO system that can both measure data in real time but which can also provide real time control opportunities that could assist the University electrical engineers in the day-to-day management of the power system. Opportunities exist for theoretical analysis along with hardware and software development. An ideal outcome of a project running in this area would be something that further developed the capability of the campus monitoring system or something that saw the system be able to interact with building users to try and incentivise a reduction in power demand throughout the whole day or at specific times.

Example projects that could be offered as part of this theme would be as follows (although it should be noted that students are encouraged to carry out their own research before the initial project meeting to allow them to identify any other areas in which they would like to work):

- Development of sensors to place within the substation and monitor parameters such as partial discharge
- Use of voltage and current data from the monitoring system to develop a dynamic rating scheme to allow equipment to be overloaded
- An assessment of the ability of the University power system to accept the introduction of local generation schemes (such as wind / photo voltaics)
- Production of live link displays that highlight building energy use to users to assess the impact this has on energy use
- Prediction of future energy demand based on historic data
- Development of phasor measurement units based on GPS techno-logy to allow coordinated cross-campus power flow measurements
- Development of a local security scheme to alert the University engineers of unauthorised substation access
- Analysis of control algorithms for network reconfiguration for minimisation of losses / control of voltage levels

Students opting for this project theme will be supervised by Professor Ian Cotton and will be expected to work closely with a number of PhD students who are engaged in work relating to smart grid systems. At the initial meeting of the students engaged in this project area, a discussion would be held between all students to determine the areas they wish to work."

Unlike the standard projects, no details regarding the specific work that was required for each student nor a listing of pre-requisite knowledge was given. In fact, within the topic students were encouraged to actively engage and come up with research areas themselves that would then be discussed during the first meetings with the supervisor.

Similar to the standard projects students would select themed projects provided entries were given regarding the type of activity they preferred (software, hardware, digital/analogue electronics, etc.).

More recently a template for a themed project was developed and generally consists of three elements:

- A structured learning (instructional) phase, in which the students will learn to use design, analysis or simulation tools, software and hardware. Technical literature study may be required and class sessions may be held. This phase may last for around two weeks.
- A design phase. Projects will be individual from this point, each student having a design hypothesis to prove. This phase will use the expertise and knowledge gained in the first two weeks to solve an engineering problem, which might involve design and fabrication/hardware construction, simulation, programming or other work using the facilities provided.
- The final phase will generally concentrate on testing of the student's design or hypothesis and further development.

4 JOINT PROJECT DELIVERY 2011/12

During the 2011/12 academic year the delivery of standard, themed and student initiated individual projects was first implemented for the full cohort of 136 students. Of these, 12 students performed self initiated projects and 20 students were allocated to one of the three themed projects. The themed projects were very popular with over 40 students selecting one of the three themes. Selection of the students admitted to the themes was dictated by their average performance during their second year of studies.

Student initiated projects where judged on their scope and deliverables, taking into account the projected costs; suitable supervisors were allocated if the project was deemed suitable. As always the majority of effort in project allocation was in finding a suitable project for students that could not be allocated a suitable standard project.

All supervisors are required to meet weekly with their students to check on progress and help with any issues that the students have. Typically supervisors would meet students individually to discuss their project taking a significant amount of their time. In contrast, supervisors of themed projects met with all students in a single common sitting. This approach has several benefits to both the supervisor and students and is appropriate for interlinked projects that are part of the themed project. The plenary weekly meetings would generally discuss how students are tackling the particular phase of their projects. For the most part the discussion would be very similar for each student, e.g. literature review, understanding what their project is, planning delivery, studying suitable methods, etc.

The collective meetings with the supervisor would initiate and support a team spirit that would continue outside the meetings themselves. Meetings with supervisors generally were lively with students discussing topics amongst themselves. This team 'spirit' creates peer pressure, which spurs on the weaker students in particular usually without intervention of the supervisor.

Supervisors should, however, monitor any alienation of students that could occur due to this peer pressure. The trials showed significant levels of student cooperation and sharing of facilities and help with debugging hard- and software problems.

Day-to-day technical and experimental support for the students through research assistants was important to further relieve supervisors. Particularly in aspects of training in software tools or handling of experimental equipment, research assistants are more suitable than supervisors since they generally have more experience with practical aspects of the work.

Because each student is expected to perform an individual project it is important to define the unique contribution to the themed project by outlining the project clearly at the onset. Due to the spread of deliverables throughout the year any tendency to 'diffuse' project contributions is counteracted and we have not witnessed any issues in this respect. The final project report holds copies of previous deliverables (project outline and progress report) as appendices so that markers can gauge project outcomes against project outline and original project planning.

Supervisors used one of two methods for conducting one-to-one supervision or surgery: as part of the weekly meeting or ad-hoc (if and when required). When part of the weekly meeting the one-to-one meetings would be conducted after the plenary part of the meeting and take between 10-15 minutes for each student. Typically a weekly meeting would take between 60-90 minutes for 6-7 students, which compares to a similar amount for the same supervisor for standard project per student in previous years.

5 CONCLUSION

The experience gained during the first year of running themed and student-initiated projects has been excellent and the School will expand the number of themes and retain the option for students to perform their own projects in the next academic year. The themed projects specifically do not merely present a very efficient way for staff to deliver the individual projects. Students performing themed projects have reacted enthusiastically and benefit from peer support and interaction.

We don't foresee changing delivery of third year project to make it completely themed based. The mix of the three types of projects is considered to be important because not all type of projects can be run as themes.

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175 TEACHING BY DESIGN: PREPARING K-12 TEACHERS TO USE ENGINEERING DESIGN ACROSS THE CURRICULUM

Louis S. Nadelson[1], Anne L. Seifert[2], Sandra G. Nadelson[3], Melinda Hamilton[4]

1.Boise State University, Boise, ID USA, Louisnadelson@boisestate.edu
2 Idaho National Laboratory, Idaho Fall, ID, USA, Anne.Seifert@inl.gov
3 Boise State University Boise, ID USA, Sandranadelson@boisestate.edu
4 Idaho National Laboratory, Idaho Fall, ID, USA, Melinda.Hamilton@inl.gov

ABSTRACT

In recognition of the instructional and curricular ties to engineering design, the potential for positive influences on students learning, and the likely lack of K-12 teacher preparation in design; we developed and implemented professional development summer institutes for K-12 teachers focused on engineering design. Our STEM summer institute used a combination of keynote presentations, group activities, content strands, and field trips to enhance attending educators' knowledge, awareness, and comfort with design and STEM education. We assessed an array of associated variables to research the effectiveness of our summer institute. Our research has revealed significant increases in comfort teaching STEM ($p < .01$) and knowledge of the design process ($p < .01$) and substantially deeper communication of the understanding of the similarities and differences between engineering design and scientific inquiry while developing a replicable professional development process.

Keywords: Teacher Professional Development, Knowledge of Engineering Design, Integrated STEM

1 INTRODUCTION

Education in science, technology, engineering, and mathematics (STEM) is fundamental to the goals of solving a myriad of international issues including meeting needs of food, energy, health, and environment. To achieve these goals requires a populace educated in STEM, who are dependent on development of highly capable and inspirational K-12 teachers prepared to teach STEM. We developed our Idaho Science, Technology, Engineering, and Math (i-STEM) initiative and subsequent i-STEM summer institutes as ongoing teacher professional development (PD) summer academies, to enhance the STEM teaching capacity of teachers in grades K-12, and involved collaborations between education, industry, business, agencies, and government. The program focused on enhancing teacher capacity to implement best instructional practices, scientific inquiry, and engineering design within the context of highly engaging learning activities that teach STEM content while attending to content knowledge, pedagogy, STEM careers, and assessment. The primary focus of our report is a response to the dearth of empirical reports documenting K-12 teacher's understanding of engineering design and subsequent abilities to conceptualize engineering design in curriculum and as part of their instruction. Further, we “pre” and “post tested” our participating K-12 teachers’ engineering design knowledge, gathering both quantitative and qualitative data.

2 ENGINEERING DESIGN IN THE K-12 CURRICULUM

Engineering design has been adopted in various forms in K-12 curriculum [1]-[7]. Although models of the design process can vary in content and emphasis of components, there are elements that tend to be common to most engineering design configurations [8]. We developed a model that condenses this process into five elements representing these fundamental aspects of design (see Table 1).

TABLE 1. Essential Elements of the Design Process used in Instruction and the Associated Processes

	Design Element				
	Problem or Goal Statement	**Criteria and Constraints**	**Generate Ideas and Select Solution**	**Process Used to Build the Product**	**Present Results and Evaluate**
Description of the Associated Process(s)	The problem to be solved/or goal is identified and explained	Criteria to which the solution must conform, and the specifications for the product are listed The constraints, limitations, or bounds for the product are recognized	Brainstorming about possible solutions to the problem Identifying what seems to be the best solution Justification and assurance that the preferred solution conforms to criteria and constraints	A solution is prototyped A solution is selected and a product is constructed	The final product is presented to others The product is evaluated for conformity to criteria and constraints and effectiveness in solving the problem Modifications inform the next version

Our intention was to simplify the design process to make it accessible and attainable for our participants (many for which this was their first formal exposure to engineering design), with the goal of increasing the teachers’ preparation to teach the processes of engineering design and engineering content while reducing their anxiety.

2.1 Engineering Design as a Context for Learning

In an exploration of the cognitive psychology literature [9]-[16], we exposed many aspects of learning that could be readily attended to using engineering design as a curricular or instructional context. Engineering design is about solving ill-defined problems [17]. Such problems provide opportunities for students engage in critical thinking and deeper learning. Engineering design is best approached when used as a multidisciplinary perspective, as an opportunity to integrate content, as a way of increasing chances for students to apply knowledge, and as a method to enhance student motivation and engagement in learning [14]. We posited that enhanced teacher awareness, preparation, and utilization of design as a context for instruction and a curricular focus was likely to lead to higher levels of teacher engagement and interest in teaching STEM.

2.2 Teacher Preparation to Teach Engineering Design

As with other reform efforts that require implementation of change, teacher adoption and adaptation of engineering design requires an investment in time, experience, and focused reflection [18]. We posited that our modeling [19] of the design process and explicit engagement of our participants in design activities would increase their engineering design knowledge. Assuming that our summer institute participants had little knowledge of engineering, we began by developing their foundational design knowledge. Most K-12 teacher preparation programs do not include engineering coursework and have limited math and science coursework, leaving a gap in teacher capacity to teach engineering concepts and use design in instruction [20]. The increasing presence of engineering in the K-12 curriculum [21],[7] provides additional justification to attend to teachers' comfort with and knowledge of engineering.

Teacher PD in STEM can have both implicit and explicit goals influencing an assortment of teacher content, pedagogical, and affective variables [22]-[24]. The connection between teacher effectiveness and their confidence and efficacy [25]-[26], the likely relationship between content knowledge and teacher effectiveness [27]-[29], and the influence of pedagogical knowledge [30] provides warrant for attending to a wide range of variables in teacher PD. We contend that STEM teacher professional development is effective when pedagogical content knowledge instruction is integrated with exposure to new STEM content. We structured our summer institute to attend to teachers' affective states in relation to teaching STEM, particularly in association with their STEM knowledge, pedagogical content knowledge, and their awareness of integrating engineering design into the curriculum. We utilized the engineering design based activities as curricular and instructional models for teaching content and processes while stimulating conversations regarding the integration of design as a context for teaching and learning STEM, linking the activities to concepts in math and science.

3 METHODS

To guide our project we used the following research questions:

- What level of understanding of the engineering design process did our K-12 educators hold and did it change due to the institute?
- How is knowledge of the engineering design process related to other characteristics of our participants?
- How did our participants perceive the similarities and difference of engineering design and scientific inquiry pre and post institute?

We anticipated that the engineering design focus of our summer institute would enhance our participants understanding of the design process. Further, we anticipated the presentations and content explicitly presenting the similarities and differences of scientific inquiry and engineering design would results in substantial increases in our participants' understanding of the unique elements and those that are shared between inquiry and design.

3.1 Participants

The 250 educators from a state in the Western United States voluntarily participated in our summer institutes were a diverse group [31]. Our participants were on average 43 years old and had taught 13.8 years. They had taken 4.4 college level science classes and an average of 3.9 college level mathematics classes. Females made up 76% of the participants and 85% of the participants were from rural or suburban communities. Teachers from K-5/6 schools made up 32% of the participants with middle/junior high school teachers representing 36%, and high school teachers representing 8%, with the remaining 25.5% coming from K-8, K-12, and alternative schools. The majority (51%) majored in elementary education, only 15% had biology or life science endorsements, and the remainder held degrees in various STEM related fields, including instructional technology, and health education.

3.2 Instruments

We prepared multiple instruments to measure the effectiveness and impact of the summer institute. The instruments included, but were not limited to, measures of; demographics, engineering design knowledge, STEM implementation, engagement in STEM, assessment of STEM teaching and learning, and comfort with teaching STEM. The instruments, results of the instruments and data collected are described in detail the "i-STEM Summer Institute: An Integrated Approach to Teacher Professional Development" [31]. These instruments were integrated in the intensive four-day summer institutes created to enhance STEM content and pedagogical knowledge of the teachers, and data collection was performed with web based questions and surveys. Instrument results were analyzed and validated by an independent third party supporting objectivity and transparency.

4 RESULTS

Design Knowledge. Our first research question asked, What level of understanding of the engineering design process did our K-12 educators hold and did it change due to the institute? To answer this question, we examined design knowledge process test composite scores. The analysis of the pre-test scores revealed that prior to the institute our participants had an average of 10.55 ($S = 3.27$) out of 18, commensurate with what might be considered to be the average public knowledge of design. Our analysis of post-institute design knowledge process test scores revealed an average of 13.03 ($S = 2.85$). We interpreted the post-institute mean to be an indicator of above average level of knowledge of design approaching knowledge commensurate with an undergraduate engineering major early in his/her program. To determine potential gain in knowledge of design, we conducted a paired samples t-test of pre and post-institute scores. Our paired samples t-test revealed $t\ (164) = 10.45$, $p< .01$, with an effect size of $d = .80$, which is considered to be large. Interpreted, our summer institute focus on engineering design increased our participants' knowledge of design by about 2.5 points, or .80 standard deviation.

Design Knowledge and Other Variables. Our second research question asked, How is knowledge of the engineering design process related to other characteristics of our participants? To answer this question we conducted a correlation analysis using the participants' post-test knowledge of design values and other measures. Our analysis revealed that design knowledge was significantly correlated with the number of college level science courses (r = .22, p< .01), with comfort teaching STEM (r = .28, p< .01), with integration of STEM into the curriculum (r=.37, p< .01), and with engagement in promoting and supporting STEM (r = .19, p< .05). The correlations with the number of college mathematics courses and years teaching at the K-12 level were not significant (See Table 2). Interpreted it appears that our participants' design knowledge is related to engagement with science learning, comfort and engagement with teaching STEM, and the integration STEM into the curriculum. However, teaching experience and mathematics learning engagement do not appear to be related to design knowledge.

TABLE 2. Correlations between Design Knowledge and Other Participant Variables.

	Design Knowledge	College level math courses	College level science courses	Years working in K-12	Comfort for teaching STEM	Integration of STEM in teaching	Engagement in STEM Teaching
Design Knowledge	--	.14	.22**	.14	.28**	.37**	.19*
College level math courses		--	.36**	.06	.18*	.21*	.14
College level science courses			--	.09	.25**	.22**	.17*
Years working in K-12				--	.00	-.11	.09
Comfort for teaching STEM					--	.60**	.45**
Integration of STEM in teaching						--	.61**
Engagement in STEM Teaching							--

*p< .05, ** p< .01

Similarities and Differences between Scientific Inquiry and Engineering Design. Our third research question asked, How did our participants perceive the similarities and difference of engineering design and scientific inquiry pre and post institute? To answer, we conducted a content analysis [32] of our participants' pre and post institute responses to the STEM Teaching and Learning assessment. We classified each of the participant's responses into four categories and the participants' pre and post institute responses, classified by category are displayed graphically in Figure 1.

Our participants' experienced a substantial decline of "no knowledge of similarities or differences" from 43% in the pre-institute to 26% in the post-institute. Our participants' abilities to "communicate the similarities of inquiry and design" shifted from 40% pre-institute to 50% post institute. Further, we detected a shift of about 8% increase in the "ability to communicate both the similarities and differences of inquiry and design" (See Figure 1).

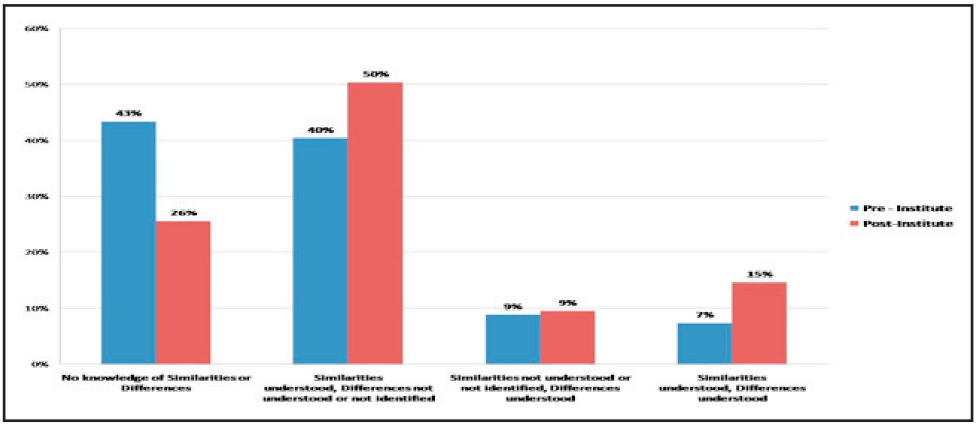

FIGURE 1. *Pre and post-institute frequencies of participants' responses.*

5 DISCUSSION

In an effort to address the call for increase K-12 student preparation in STEM, we created and implemented four day residential professional development summer institutes for K-12 educators to prepare them to teach engineering. We contend that teachers' knowledge of engineering design is fundamental for preparing them to teach using engineering design. Our results revealed that our participants experienced substantial increases in their design knowledge, indicating that our i-STEM summer institutes were successful.

Our correlation analysis revealed a number of significant relationships. We posit that the relationship with science knowledge is reflective of the overlap between inquiry and design and also the need for science content knowledge to effectively understand engineering. However, content and procedural knowledge of mathematics may diverge from design process, as our data failed to expose a relationship with this variable. Why design knowledge is correlated with science and not math knowledge is certainly a phenomenon that is worthy of additional research.

In terms of the significant relationship between design knowledge and comfort with teaching STEM, engagement with teaching STEM, and implementation of STEM measures, we contend that these relationships make apparent that notion that teacher knowledge of design allows them to feel more confident about teaching design, be more involved with teaching design, and encourages them to seek a new ways to teach design. Our findings illustrate that increasing teachers' knowledge of engineering is likely to influence their STEM teaching as a whole.

Our participants' description of the similarities and differences of scientific inquiry and engineering design revealed substantial shifts in their knowledge. Our participants were more readily able to communicate the similarities of inquiry and design than the differences. Gaining a deeper understanding of how teachers define and conceptualize inquiry and design, how teachers develop their knowledge of design and inquiry, and how hands-on activities impact teacher knowledge are excellent subjects for future research.

Limitations. Our data was collected as self report and therefore is subject to the associated limitations. While a portion of the responses were brief, we posit that interviews, recorded verbal responses, or focus groups may be more effective at capturing in depth responses. The participants in our study were mostly K-12 teachers, representing a range of subject areas and grade levels. Nevertheless, given the general lack of integration of engineering in the K-12 curriculum we feel that the outcome is representative of K-12 teachers.

6 CONCLUSION

Our STEM summer institute used a combination of keynote presentations, group activities, content strands, and field trips to enhance attending educators' knowledge, awareness, and comfort with design and STEM education. Confidence in the engineering design increased and the program is replicable, and can effectively serve diverse populations of students and teachers.

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176 PEDAGOGICAL APPROACH FOR THE STRUCTURAL STABILITY

Walnório Graça Ferreira[1], Diogo Folador Rossi[2] ,Vitor Folador Gonçalves[3] & Augusto Badke-Neto[4]

1Federal University of Espírito Santo, Vitória, Brazil, walnorio@pesquisador.cnpq.br
2 Federal University of Espírito Santo, Vitória, Brazil, rossi.diogo@gmail.com
3 Federal University of Espírito Santo, Vitória, Brazil, vitorfolador@hotmail.com
4 Federal University of Espírito Santo, Vitória, Brazil, augbadke@gmail.com

ABSTRACT

The materials used nowadays in buildings are being replaced by ever more resistant ones, allowing for larger structural spans. This has been used by architects to satisfy the wishes of their customers, and everybody becomes happy because of longer spans without columns. Thus, the whole supporting structure becomes slender. Consequently, structural elements under compression are more subject to large lateral deflections, being susceptible to loss of stability, requiring second-order analysis. This article first presents a conceptual approach with regard to the theory of elastic stability, including the terminology involved as a bifurcation, critical load, limit points, jump dynamics and post-critical path. In a second step, this paper presents a didactic computer-numerical procedure for stability analysis of nonlinear systems with one and two degrees of freedom, without loss of generality involved in complex systems that need the finite element method for the solution. This approach will be of great value not only for teaching the theory of elastic stability at the undergraduate level, but also for teaching at graduate level, since it introduces details of computational implementation, the concepts of stability, analytical solution of geometrically nonlinear systems, as well as incremental-iterative solution based on Newton-Raphson method, using simple mechanical models consisting in rigid bars and rotational and linear springs.

Keywords: Nonlinear analyses, Structural stability , Buckling.

1 INTRODUCTION

Creating the most economic structures through reduction of material consumption and overall weight without loss of safety and durability has been the main objective of structural engineering.

Weight reduction has been achieved in concrete structures, by increased use of high-strength concrete (generally greater than 20 MPa), especially those with resistances greater than 50MPa, and steel structures with resistances exceeding 250MPa. Associated with the use of refined analysis and more accessible and powerful computers, this has led to bolder projects with thinner structural elements. Consequently, compressed structural elements are more susceptible to large lateral deflection, increasing the possibility of loss of stability, demanding nonlinear analysis. This phenomenon is analyzed with adequate depth in the theory of elastic stability [1]. This work aims to present concepts and terminology relevant to the loss of stability of structural systems which are often not approached with adequate depth in the solid mechanics books at undergraduate civil engineering and mechanical engineering courses.

2 CONCEPTS OF STABILITY

The stability of equilibrium is a basic concept of rigid body mechanics, which can be easily viewed and intuitively assimilated through the classic problem of spherical mass lying in straight or curved surfaces, as illustrated in Figure 1.

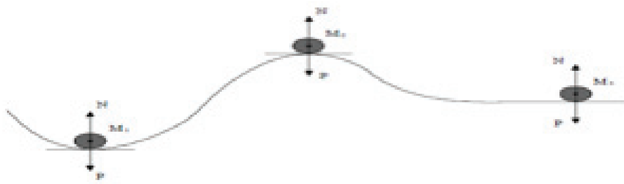


FIGURE 1. *Spherical masses in static equilibrium.*

The points where the masses M1, M2 and M3 rest have zero slope and represent points of static equilibrium, however, the type of equilibrium achieved at each of these points is essentially different. If the mass M1 undergoes a small external disturbance, when the cause of trouble is removed it returns to the starting equilibrium position. In this case, the original position is considered a stable equilibrium state. It is observed that in this case, the center of gravity rises, thus increasing the potential energy of the system ($\Delta\Pi > 0$). For mass M2, unlike what happened with mass M1, the original position is an unstable equilibrium state, because after a small disturbance, the static forces acting upon the system tend to displace the ball away from the equilibrium position. In this case there was a lowering of the center of gravity and, consequently, a decrease in the potential energy of the system ($\Delta\Pi < 0$). In the third case, when the weight rests on a flat surface, the system is referred as being in a state of neutral stability (or state of indifferent stability), i.e., in any position the ball remains in equilibrium. Here the center of gravity of the ball remains at the same level, and therefore no variation in the potential energy occurs ($\Delta\Pi = 0$, [1]). To study the stability of structural systems, three criteria can be used. The static criterion of stability, which examines the equilibrium of forces, the energy criterion of stability, which examines the variation of the total potential energy, and the dynamic criterion of stability, based upon concepts from vibration theory.

The loss of stability is a nonlinear phenomenon. Therefore, to understand, accurately,

the behavior of the system under this effect, one has to use nonlinear analysis. When analyzing the stability of a structural system, a set of control parameters is used. To understand the overall behavior of the system and identify the possible instability phenomena, the variations of the equilibrium position with respect to changes in each control parameter have to be studied. Thus, the so-called equilibrium paths are obtained. Along these paths, the equilibrium configurations may be qualitative changes with regard to their stability. The border points are called critical points, that which can be of two types: bifurcation points or limit points [2].

3 NONLINEAR BEHAVIOR OF MECHANICAL SYSTEMS

3.1 Stable-symmetric bifurcation system

3.1.1 Analytical nonlinear solution

In real cases, the structures often have imperfections: there are no perfectly straight bars. Thus, a way to consider these defects is to allow the bar to be initially at an angle θ0 with respect to its vertical position, as illustrated in Figure 2.

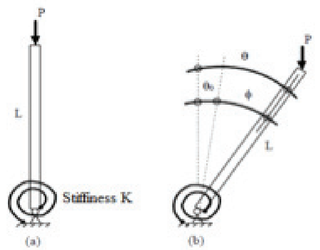


FIGURE 2. *System showing a no weight rigid bar with imperfections and circular spring.*

Table 1 shows the equations of potential energy of elastic spring, the potential of P and the total potential energy (Π = U + V).

TABLE 1. Total potential energy of system with imperfections.

Potential energy of elastic spring	Potential of load P	Total potential energy
$U = ½\ K\varnothing^2 = ½\ K(\theta - \theta_o)^2$	$V = -P\Delta = -PL.(\cos\theta_o - \cos\theta)$	$\Pi = ½\ K(\theta - \theta_o)^2 - PL.(\cos\theta_o - \cos\theta)$

For the energy criterion of stability, the system is in equilibrium (stable, unstable or indifferent) when the equation dΠ/dθ = 0 is satisfied, or when:

K(θ − θ0) - PL sin θ = 0 (1)

This equation shows that θ = 0 is no longer the problem solution. Isolating P in equation (1),

P = K(θ − θ0)/ L sin θ (2)

The following figure shows the critical paths for the system of Figure 2.

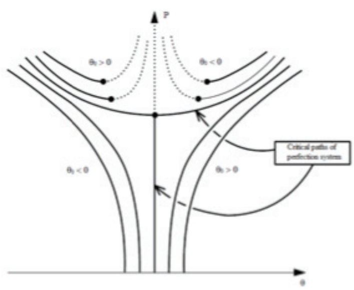


FIGURE 3. *Nonlinear solution of system of Figure 2*

The Figure 3 shows the critical paths of the imperfect system illustrated in Figure 2,

along with the those of the perfect system . It is observed that there is no bifurcation, the solutions of the nonlinear imperfect system bordering the solutions of the perfect system (there is an asymptotic approximation.) The paths above the perfect system curve are called complementary equilibrium paths [3] and can only be achieved in dynamic problems. This example presented the equations for the total potential energy and the equations resulting from applying the energy criterion of stability. Further are presented other examples of mechanical stability without the equations deduction, since nothing conceptually new stands on these deductions. In the following examples concepts and terminology will be discussed, the true objective of this work.

3.1.2 Numerical nonlinear solution using Newton-Raphson procedure

The numerical solution is performed by an iterative process involving two stages. The first step involves the incremental offsets from a given load increase, where unbalanced forces appear. The second stage is a correction process, when searching the equilibrium of forces, using a convergence criterion, until

$F_{int} – F_{ext}$ 0 (3)

Where F_{int} is the internal force, a function of displacement, and F_{ext} is the external force.

Consider now the case to solve, through this procedure, the nonlinear problem of the mechanical system illustrated in Figure 2. In this case, $F_{int} = K(\theta - \theta 0)$ and $F_{ext} = PL\sin\theta$ and $F_{int} - F_{ext} = K(\theta - \theta 0) - PL\sin\theta$ is the unbalanced force. The methodology for solving nonlinear systems used in this study,

which is based primarily on the iterative-incremental solution of Equation (3) is shown in Table 2 below.

TABLE 2. Solution strategy nonlinear through the Standard Newton-Raphson method .

1.	Initial configuration: θ_0	
	Increases P	
	Increases P	
3.	Iterative cycle (internal loop, Newton-Raphson iteration)	
	a.	It calculates the second differential of Π
	b.	It calculates the unbalanced load vector $F_{int} - F_{ext}$ (first differential of Π)
		If true, it returns to item 2
		If true, it returns to item 2
		$\theta = \theta - (d\Pi/d\theta)/(d^2\Pi/d\theta^2)$
		It returns to item 3

3.2 Unstable-symmetric bifurcation system

Figure 4 shows a system consisting of a vertical bar with compression load P at the upper end associated to a linear spring of stiffness K. Figure 4 (a) shows the system in its initial state, and Figure 4 (b) present it in the disturbed state.

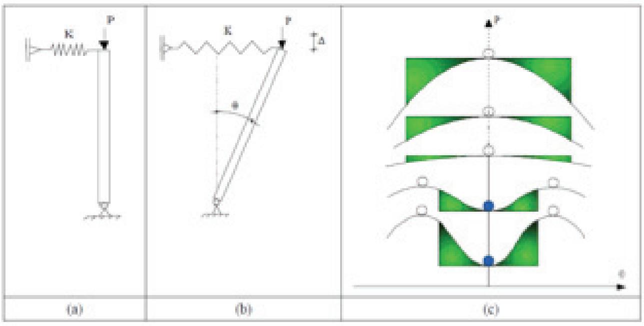


FIGURE 4. *Rigid bar with spring linear, variation of total potential energy and the analogy with spherical mass.*

The analysis of this system shows that for P <KL, the equilibrium is stable, but when P>KL, the path is the postcritical and it is always unstable (Figure 4 (c)), with symmetric bifurcation. This case is known as unstable-symmetric bifurcation system [4].

3.2.1 Effect of initial geometric imperfections

The imperfections in this system are treated similarly to the case of the rigid bar with circular spring (Figure 2). Figure 5 shows behavior.

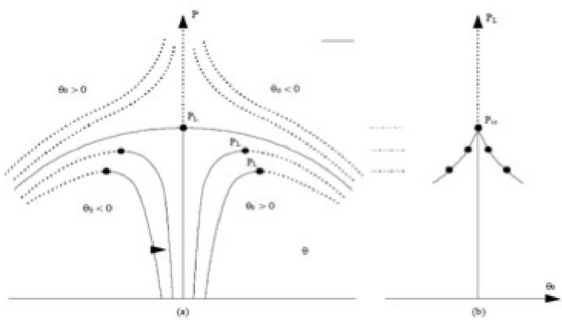


FIGURE 5. *Nonlinear solution of the system of figure 4 with imperfections and variation of limit load with imperfections.*

In this system, is verified that starting from the P = 0 (when θ0> 0), the critical path is stable until it reaches a maximum value represented by PL, from which it becomes unstable. The load is called buckling load or limit load of the imperfect structure and the corresponding point is called a limit point (point limit load). From the limit point there is instability with the strains growing indefinitely (Figure 5 (a)). This process of loss of stability is called dynamic jump. As it increases θ0 imperfection of the system, the limit load becomes lower (Figure 5 (b)).

3.3 Asymmetric bifurcation system

The system is illustrated in Figure 6 (a): a rigid, initially vertical, weightless bar, with a 45º inclined linear spring when unloaded.

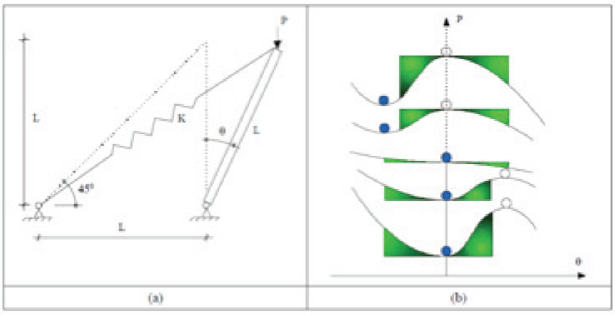


FIGURE 6. *Asymmetric bifurcation system.*

The Figure 6 (b) shows the behavior of this system. Negative disturbances (θ <0) cause stable equilibrium. Positive disturbances (θ> 0) lead to a critical path with limit point, the limit load being the highest load the system can support. In civil engineering, the non-symmetric plane frames may exhibit this behavior.

3.4 System with no bifurcation

The structure shown in Figure 7 (a) consisting of two rigid bars freely hinged to each other and with two supports: support C attached to a linear spring of stiffness K. Both the bars, have initial θ0 slope.

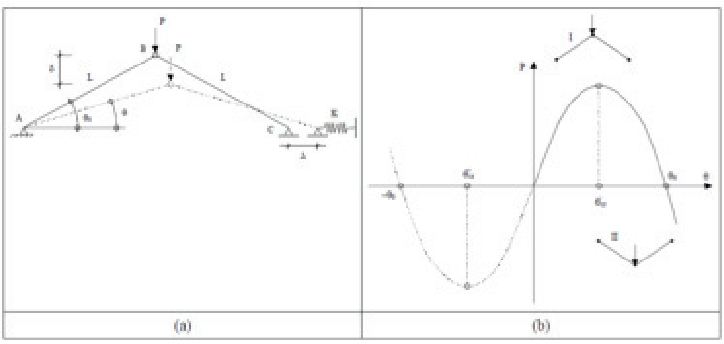
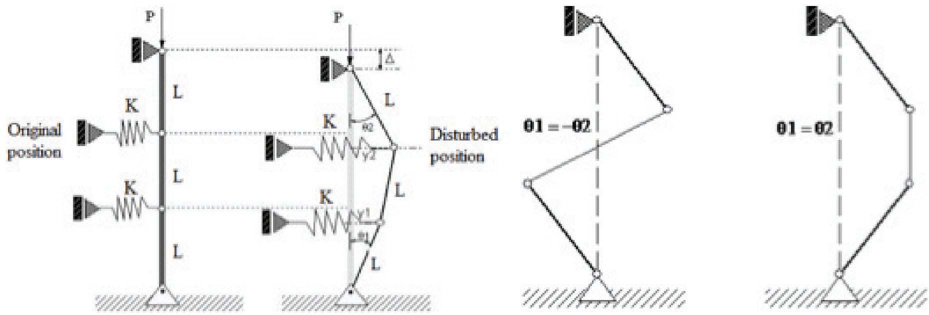


FIGURE 7. *System with no bifurcation.*

Comments will be made only for θ> 0. By increasing load P from zero, the angle θ, which is downloaded to the system value θ0, will decrease until it reaches a critical point θcr '. An infinitesimal increment greater than this value there will be a sudden change in system configuration, passing the configuration I to configuration II (Figure 7(b)). This sudden change of configuration is called a dynamic jump.

3.5 Systems with multiple degrees of freedom

In this study, using the energy criterion of stability, a structural model with two degrees of freedom, consisting of three rigid bars, with no weight and length L each.The bars are freely hinged to each other . At the lower end there is a pinned support and at the top a roller support. The model is supported by two linear springs with stiffness K and it is subject to a compressive vertical load. All concepts that were seen for systems with single degree of freedom are valid for systems with multiple degrees of freedom. Thus, only a compact representation of this system of equations for two degrees of freedom will be presented.



(a) (b)

FIGURE 8. *Proposed structure for analysis and configuration mechanism after it loses stability.*

For structural system shown, one defines the potential energy from values y_1, y_2 and Δ, as follows

U(θ1, θ2) = (1/2)K.y1² + (1/2)K.y2² (4)

V(θ1, θ2)= - P . Δ (5)

Thus,

∏(θ1, θ2) = (1/2)K.(Lsin(θ1))² + (1/2)K.(Lsin(θ2))² + [-P.[3.L-[Lcos(θ1) + Lcos(θ2) + L.[1-[(sin(θ2) - sin(θ1))²]1/2]]]]

Now, using the Principle of Stationary Potential Energy, the pair of equations of nonlinear equilibrium becomes:

dΠ(θ1, θ2)/dθ1 = 0

Thus,

KL2.sin(θ1). cos(θ1) – P.[L sin(θ1) – [L. (sin(θ2) - sin(θ1)). cos(θ1)]/[1- (sin(θ2) - sin(θ1))²](1/2)] = 0

And

$d\Pi(\theta 1, \theta 2)/d\theta 2 = 0$

Thus,

$KL2.\sin(\theta 2).\ \cos(\theta 2) – P.[\ L \sin(\theta 2) – [L.\ (\sin(\theta 2) - \sin(\theta 1)).\ \cos(\theta 2)]/[1- (\sin(\theta 2) - \sin(\theta 1))^2]\ (1/2)] = 0$

So, the procedure follows as seen to single-degree-of-freedom systems. The Figure 9 shows the nonlinear behavior of system shown in Figure 8.

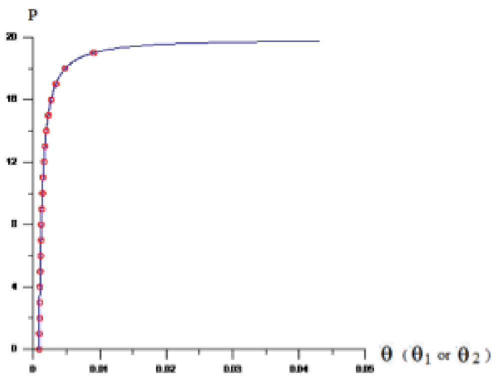


FIGURE 9. *Nonlinear solution of the system of figure 8.*

This article aims to present relevant concepts and terminology of the theory of structural stability. To achieve this, mechanical models with rigid weightless bars associated with circular or linear springs were used. By studying the stability of these simple models all the concepts and behaviors commonly used to study the stability of real structures have been discussed, such as plane frames, arches and others. This text is an important teaching aid in this subject, for students, also serving as a pedagogical support to teachers in the basic disciplines and professional courses in civil and mechanical engineering, not familiar the geometric nonlinear analysis.

4 ACKNOWLEDGEMENTS

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177 COMPARISON OF GRADUATE COURSES IN TEACHER TRAINING SCHOOLS OF ENGINEERING

Luciana Guidon Coelho[1], José Aquiles Baesso Grimoni[2] & Osvaldo Shigueru Nakao[3]

1 Polythecnic School of University of São Paulo, São Paulo, Brazil, luciana.coelho@usp.br
2 Polythecnic School of University of São Paulo, São Paulo, Brazil, aquiles@pea.usp.br
3 Polythecnic School of University of São Paulo, São Paulo, Brazil, osvaldo.nakao@poli.usp.br

ABSTRACT

Our aim is to present and analyze some graduate courses in teacher training of engineering schools and to propose a course for the University of São Paulo. The existence of such courses arises from the need for further training lecturers in most engineering courses. Usually they are engineers, many with graduate (masters or PhD levels), but without adequate training for the educational field. For this reason, the classes are often expositive, the lecturer is the center of the process, and the one who concentrates the information, passing it on to his/her students, who have a passive participation, which may culminate in a teaching - learning process that does not attain its goals.

Keywords: Engineering education, Training engineering lecturers, Graduate courses in engineering education.

1 INTRODUCTION

This paper presents some graduate courses in engineering education from American universities and also a course designed by UnB (University of Brasília), Brazil. Such courses, researched only on the internet, intended to assist lecturers and future lecturers to build capacity to improve their lessons and gain knowledge of the pedagogical field. "Teaching in graduation requires the teacher to dominate the pedagogical area, but in Brazil this does not happen when talking about professionalism in teaching, either because they see it as something superfluous or unnecessary for education, or because they have never had the opportunity to get in touch with this area." [1]

In the courses investigated, there is an increasing use of new technologies as tools used in class and also the integration of disciplines. With respect to the latter topic, it is observed that several of the courses investigated focus on the education called STEM (Science, Technology, Engineering and Mathematics Education), which integrates these concepts.

Graduate programs (masters and/or PhD courses) will be presented and discussed. Also, an analysis of the courses investigated will be presented and an initial proposal for the creation of a graduate course in engineering education at the University of São Paulo.

2 GRADUATE COURSES

2.1 Virgínia Tech

Virginia Tech has a PhD program primarily designed for the development of top-level educators and researchers. The aim of the course is to be innovative, to promote inclusion and interdisciplinarity, and to be international. Advanced researches are conducted in the emerging segment of engineering education and simultaneously seek to develop and deliver significant experiences in teaching-learning for future engineers and educators. For the conclusion of the course, 90 semester hours, training of 12 semester hours and dedication to research and thesis of at least 30 semester hours are required. [2]

2.2 Carnegie Mellon University

The PhD program in interdisciplinary education is part of the PIER program (Program for Interdisciplinary Education Research), the goal of which is to prepare researchers familiarized with many of the fundamental problems of education in the U.S. and engaged in applying their skills and knowledge to solve these problems, and having knowledge in cutting-edge theories and methodologies in cognitive and developmental psychology, statistics, human-computer interaction and instructional technology. For graduation, at least 60 semester hours are required, distributed across elective and core disciplines, 1 year of training and thesis preparation. [3]

2.3 University of Arizona

The PhD in engineering education facilitates students' original research into this innovative field and encourages them to develop a strong interdisciplinary focus, drawing from the resources of the university and collaborating units. Students will present a dissertation that describes an original contribution in engineering education with an emphasis on teaching, learning, curriculum design, assessment and evaluation within a chosen context. This program prepares students to critically analyze and conduct research in engineering education and to explore the art and science of engineering learning. The program is guided by faculty mentors representing the Mary Lou Fulton Institute, the Graduate School of Education and the Ira A. Fulton Schools of Engineering. At least 63 semester hours are needed, plus 6 semester hours of training and 15 semester hours for research and thesis preparation. [4]

2.4 University of California - Berkeley

The PhD program in science, mathematics, or engineering education (STEM) is designed to produce graduates who have advanced expertise in a scientific discipline as well as in educational theory and research methodologies. The course is offer by SESAME (Graduate Group in Science and Mathematics Education). The Group was formed in 1968 by several Berkeley faculty members from science and mathematics departments. It is formally called the Graduate Group in Science and Mathematics Education, but the acronym is still used. Many of the students' projects are concerned with college-level teaching in their disciplines.

Others are concerned with curriculum development for elementary and secondary schools, research into cognitive processes underlying good performance in scientific domains, investigations of principles for the design of computer-based educational software, or studies of informal learning in science museums and other places open to the public. Until 2010, there were 39 thesis and dissertations in the university's website. For graduation, it is necessary to complete two semesters of seminars (practice in science and mathematics education), four semesters of colloquia (research seminar and symposium); it is also necessary to choose a course on cognition (out of the several that are offered), a course on discipline, a course on curriculum and a course on technology and methodology. [5]

2.5 Ohio University

The STEM education area of study at The Ohio State University has long been ranked among the best in the country and attracts students worldwide. The PhD program provides the basis for cognitive development, learning, teaching and social contexts in which they occur. The main research lines are: lecturer education, instructional technology, cognitive development, cognitively active learning, conceptual change, evolution education, nature of scientific knowledge and inquiry, curricular integration, social justice and urban education. 72 semester hours are required for the core disciplines and 12 semester hours are required for the elective disciplines. [6]

2.6 Purdue University

Purdue has been a powerhouse for educating engineers for more than 130 years, but the scholarly study of how to best educate engineers has only emerged in the past few decades. Determined to lead in the discipline, in 2004, Purdue established the Department, now School, of Engineering Education (ENE), the world's first such academic unit, and, along with it, the world's first engineering education doctoral program. The purpose of the program is that students develop rigorous research on how to improve teaching, learning and practice of engineering. 90 semester hours are mandatory for graduation. [7]

2.7 Tufts University

The program admits candidates graduated in mathematics, biology, chemistry, physics, technology, engineering, education, psychology or related areas. Students must commit to understanding the problems and challenges involved in research and practice of mathematics, science and engineering education .The master's and PhD program is called MSTE Education (graduate program in Mathematics, Science, Technology, and Engineering Education). Each student must necessarily complete 20 credits for graduation. [8]

2.8 University of Utah

The Doctorate of Philosophy in Engineering Education is offered through the Engineering Education department (EED). An emphasis is placed on utilizing engineering skills and methods to conduct rigorous educational research to investigate educational problems affecting engineering and the larger STEM (Science, Technology, Engineering, and Mathematics) community. The intention is that students are able to develop projects in engineering education, dicipline plans, inclusion of technology in education, among others. For graduation, 60 semester hours are required, including disciplines and research. [9]

2.9 University of Brasília

The graduate program in engineering education (master and PhD) would focus on scientific research related to the theory and practice of education in technology and engineering, improvement and completion of lecturer training through continuing education and building learning experiences for future educators. The course was under construction at the time of this research baseline (2010). [10]

3 ANALYSIS OF THE COURSES

Except for the course offered by the University of Brasilia, all other courses presented in this work are offered in American universities. It is a fact that engineering education is different in the United States and Brazil, which complicates a comparison of the Brazilian and the American courses and also concerning the needs of Brazilian graduate master's and doctorate degrees in engineering education with the training offered in the courses listed.

It is a fact that the creation of graduate courses in engineering education is based on the realization that the existing approach to educating future engineers, using mainly non-participatory techniques, is not appropriate. Thus, the main objective of these programs is to transform the way students are educated in schools of engineering and applied sciences, especially during the early years of training.

The graduate programs in engineering education prepare the next generation of leaders and experts to develop improved strategies for engineering teaching and learning. The courses try to offer a multidisciplinary academic experience, which combines fundamental research and best practices to enhance learning.

All courses presented have disciplines and/or research areas related to the integration of technology in teaching and study of the cognitive sciences, which leads us to believe that there is a clear need for the use of technology in engineering education, and lecturers need to know about how, when and why to use these teaching techniques.

The following is a table with some disciplines of the universities that had this information on their web sites. This is not necessarily the title of the course, in some cases it is the content to be studied.

4 PROPOSAL FOR A COURSE FOR THE UNIVERSITY OF SÃO PAULO

4.1 Justification and format of the course

At the University of São Paulo (USP), there are a lot of discussions about improving teaching, many events have been held, the Seminars in Education inside the University as an example, classes and trainings of the Teaching Improvement Program.

A serious problem observed and one of the motivations for the development of a graduate course in engineering education is the "productivity measurement" by the number and quality of publications, which causes a preference for research over teaching, especially at the undergraduate level. [11]

TABLE 1. Disciplines.

Virginia Tech	Arizona	Berkley	Ohio	Purdue	Tufts	Utah
Foundations of Engineering Education	Foundations of Engineering Education	Curriculum Development & Instruction in Science	Logic and Psychology in School Science/Mathematics	Theories of Development and Engineering Thinking	Human Development and Learning	Evaluation and Assessments
Design in Engineering Education and Practice	Assessment and Evaluation in Engineering Education	Problem Solving and Understanding	Statistics	History and Philosophy of Engineering Education	Psychological Studies in Education	Role of Cognition in ENE
Design of Laboratory Courses for Engineering Education	Research Methods in Engineering Education	Discourse and Learning in Math and Science Classrooms	Theoretical Perspectives on Learning and Teaching as Change Processes	Leadership, Policy and Change in STEM Education	Contemporary Socio-cultural Perspectives on Teaching and Learning	Foundations of ENE
Communication in Engineering Curricula: Theory, Practice, and Pedagogy	Cognate Study	Cognitive Science Approaches to Learning	Quantitative Research Design, Analysis & Interpretation	Pedagogy, Content, and Assessment	Cognitive Psychology	Educational Foundations
Evaluating Engineering Communication Assignments	Engineering Education Practicum: Applied Project	Mathematical Thinking and Problem Solving	Current Issues and Trends in STEM education	Cognitive Engineering	Philosophies of Education	Program Design
Assessment Techniques in Engineering Education	Interdisciplinary Research Seminar in Curriculum and Instruction	Scientific Thinking and Learning	Advanced Study of Thinking, Learning, and Assessment in Mathematics or Science Education.	Models & Modeling Perspective in Engineering Education	Technological Tools for Thinking and Learning	Foundations of Curriculum
Practicum in the Engineering Classroom	Curriculum Theory and Practice	Instructional Design in Science/Mathematics Education	History of Mathematics, Science, or Technology Education.	Cognitive Devices in STEM Learning Environments	Theory and Research in Engineering Education	Teaching & Learning Foundation
Engineering Education Research Methods	Educational Technology.	Technology, Curriculum and Instruction	Psychology		Quantitative and Qualitative Research Methods	Qualitative Methods
	Qualitative Methods and Quantitative Methods.	Qualitative Methods and Quantitative Methods.			Theory and Research in Technology and Science Education	Research Design and Analysis

It was also noted that the conception of teaching as a gift carries the prestige of academic status, relegating teaching knowledge to a background and devaluing this field of teacher training. Besides, the pedagogical knowledge was formed far from the university experiences and only later reached some scientific legitimacy. In general, the main focus of teaching was a child, honoring the Greek origin of the word. [12]

The practice of teaching is never static and permanent. It is always changing, it is moving, it is an art, and there are new faces, new experiences, new context, new time, new place, new information, new feelings and new interactions. This concept, however, contradicts the historical assumption built into the teacher's work, embodied in the idea that the teaching practice is summarized in teaching some knowledge established and legitimized by science and culture. [13]

The proposed graduate course on engineering education from the Polytechnic School of the University of São Paulo is held on the previous findings. For structuring the course, it is necessary to consider various aspects, such as how to involve older lecturers/professors, who may no longer focus on improving their lessons, lecturers taht prioritize research, the students' opinions about the classes and lecturers, the expectations of undergraduate students who pursue teaching, the possibilities of change allowed by the university and many other aspects.

The proposal made in this paper is just an initial outline of the course content and the factors that should be considered for its creation. First, it is thought to structure a course which is called "professional master's" in Brazil, which differs from the academic master's courses offered by USP.

According to the new rules of graduate studies of the University of São Paulo [14], "the professional master's has the characteristics of a master's course in the strict sense, developed under the supervision of a mentor. Comprising a set of planned activities, with a structure analogous to that of the master's of an academic nature, with thematic research demanded by sectors outside the University, such as business, service, finance, public policy, among others. The research developed in the professional master's of an applied nature, i.e., seeking a more limited universe of knowledge and application in the short and medium term."

4.2 Disciplines Contents

The proposed course for the USP should be mandatory disciplines and the possibility of the student attending elective ones within or outside the Polytechnic School; for example, taking courses in other units of USP, such as the Faculty of Education, the Institute of Psychology or the Faculty of Humanities. The student will take about 10 disciplines (about 30 hours each, using Distance Education support) supported by centers distributed at various campi of USP in the State of São Paulo. Students will develop a dissertation on a topic of interest of their institution, which will be presented before a board of referees. The student could complete the program in two years.

Based on the main disciplines offered in courses in the USA (Table 1), it is expected that the mandatory subjects of the Brazilian course are, among others, the following topics: history of science, technology, engineering and engineering education; engineering and society; structure and functioning of education in Brazil; definition of educational objectives; insertion of new technologies in education; distance education; educational project; planning of courses curricula and disciplines; communication theory; techniques and strategies in the classroom; assessment tools; teacher-student relationship; educational psychology; cognitive science; instructional design; statistics; quantitative and qualitative methods and methodology of scientific research. Some other important topics to be explored in the disciplines are: higher education methodology; cooperative learning environments supported by new technologies; new models of teaching and learning; knowledge in the classroom: the organization of education; higher education policies in Latin America and teaching practices.

Also to be considered for the basic structure of the course: discussions; lectures; possible exchanges of students and teaching training.

5 CONCLUSIONS

The development of new technologies in the field of information and the changing paradigms in education are the causes why teaching and learning of engineering must be adapted to new methods, making use of teaching tools and technology available. Thus, graduate students in engineering education are doing researches looking for the best strategies applicable in the education of future engineers.

In this context, the traditional teaching strategies, focused on the teacher as an inexhaustible source of knowledge, along with the attitude of passive learning by students, are being gradually replaced by a less vertical and more participatory education, in which the relationship between teachers and students supposes a joint search for new knowledge.

The aims of graduate programs in engineering education investigated in this paper is to train teachers and researchers in teaching and learning methodologies which are constructivist and multidisciplinary, able to develop not only knowledge objectives, but attitudinal objectives, able to train competent students, critics and leaders. The aims of the course desired for the University of São Paulo are the same.

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178 WORKFORCE DEVELOPMENT IN NANOSCALE SCIENCE AND ENGINEERING - TRAINING TEACHERS TO EDUCATE FUTURE NANOSCALE SCIENTISTS AND ENGINEERS

Nancy Healy[1] & Joyce Allen[2]

1,2 Georgia Institute of Technology and the National Nanotechnology Infrastructure Network, Atlanta, GA, USA, nancy.healy@mirc.gatech.edu, joyce.palmer@mirc.gatech.edu

ABSTRACT

Nanoscale science and engineering (NSE) is a truly interdisciplinary endeavor in that it combines engineering, chemistry, physics, physical science, and biology. Workforce needs of NSE are estimated to be 2 million worldwide by 2015 with another 5 million in support positions. To meet the need of an educated populace that can work in the field as well as support its safe development, it is critical to provide high-quality nano-education programs for K-12 teachers. Teachers will play an important role in this workforce development issue. The Georgia Institute of Technology's National Nanotechnology Infrastructure Network (NNIN) site has been developing and implementing a professional development program in NSE education for science teachers. The primary focus of our program has been to help teachers understand how nanotechnology can fit into a standards-based science curriculum. Our work with teachers in a variety of programs has led to insights into what is needed to incorporate NSE topics into the classroom.

Keywords: nanotechnology education, teacher professional development, workforce issues.

1 INTRODUCTION

Science, technology, engineering, and mathematics (STEM) education in the United States has been the subject of much attention because of its importance in our economic well-being and quality of life. In Rising above the Gathering Storm, it is noted: "Without high-quality knowledge, intensive jobs and innovative enterprises that lead to discovery and new technology, our economy will suffer and our people will face a lower standard of living." [1] Much of this economic prosperity lies upon a STEM-capable workforce yet many indicators demonstrate that our educational system is not producing a scientific-literate population. NAEP 2009 results found that just 34 percent of fourth graders, 30 percent of eighth grades and 21 percent of twelfth graders were rated proficient or higher and more than one in four scored below the basic level [2]. In mathematics (2011), 40 percent of fourth graders and 35 percent of eighth graders scored at or above Proficient which is the highest since the assessment began in 1990[3]. PISA results rank U.S. students 18 in mathematics and 13 in science against thirty-three other countries [4]. There is also great disparity in student readiness for more advanced learning with only 45 percent of U.S. high school graduates in 2011 ready for college mathematics and 30 percent for college science [5].

This poor showing in national and international assessments has increased interest in STEM education in the U.S. with several new initiatives aimed at increasing STEM literacy in students and the general population. Added into this mix of STEM initiatives is the need to include nanoscale science and engineering (NSE) into current STEM learning. Why should NSE be part of this learning? The National Science Foundation (NSF) estimates that by the year 2015 there will be a need for two million workers worldwide in the fields of nanoscience and nanotechnology [6]. Global market estimates for NSE technologies are $1trillion by 2015 and $3 trillion by 2020 [10]. The need for a skilled workforce to meet this challenge has been highlighted in numerous reports [7-9], which stress the critical importance of technological innovation in U.S. competitiveness, productivity, and economic growth. Nanotechnology is seen as one of these technologically important fields and as noted in Innovate America, "nanotechnology could impact the production of virtually every human-made object".[10] While the U.S. is noted as a leader in nano-education resource materials, Taiwan and Australia are considered to have more developed and sequenced K-12 nano education programs.[7] We see nano-education as an opportunity to excite students about current science and engineering topics and a way to connect ideas and concepts between scientific disciplines. The unique properties of the nanoscale can be a platform to encourage students to explore STEM fields as potential careers. "In fact, as NSE is pervasive to all areas of science, both conceptually and in application, it may be best addressed by embedding it throughout all science courses." [11] This paper reports on our efforts to develop a professional development program for teachers which shares methods on how to incorporate NSE into standards-based curricula.

1.1 The National Nanotechnology Infrastructure Network – Education and Outreach Programs

The National Nanotechnology Infrastructure Network (NNIN) is a NSF-funded program which supports nanoscience researchers by providing state-of-the-art facilities, support, and resources. The NNIN is a partnerhsip of 14 U.S. universities (http://www.nnin.org). which provide researcher support and has an integrated and varied education program. Our goals are to develop a nano-ready workforce, excite students about STEM, and develop a nano-literate public. Our outreach starts with elementary grade students and teachers and spans to adults in need of retraining and skill enhancement. As part of this, we offer professional development to teachers so that they will know how to include NSE topics in their curriculum. With this, we also hope to excite secondary and post-secondary students to enter the STEM fields and in particular, nanotechnology.

1.2 NSE Professional Development for Teachers

The NNIN site at Georgia Institute of Technology set as one of its goals the development and implementation of teacher professional development (PD) workshops in NSE. Over the past decade, educational researchers have determined what entails good PD for teachers. An analysis of PD noted that teachers need strong content knowledge and the ability to change their pedagogy. [12] Other research clearly demonstrate that PD should be of sufficient duration, focused on specific content, provide instructional strategies, consist of teams of educators, and demonstrate active or inquiry-based learning.[13]

Research has now begun on what makes good professional development (PD) in NSE as well as what NSE topics are of interest to students [14]-[17]. Numerous publications related to NSE teacher PD and instructional materials can be found in several publications and the references therein. [18]-[20]. One study, noted that it is critical to demonstrate to teachers how to incorporate NSE into existing curricula while incorporating strong content and pedagogy in the PD [21]. Other studies indicate that NSE can help increase teacher content knowledge

We have developed our PD workshops based on the idea of demonstrating to teachers where NSE concepts fit into standards-based curriculum. Our workshops focus on the Big Ideas in Nanoscale Science and Engineering [22]. These include: structure of matter; size and scale; forces and interactions; size-dependent properties; quantum effects; self-assembly; tools & instrumentation; models and simulations; and science, technology and society. The "Big Ideas" serve as a resource for connecting nanoscience and current science curriculum as well as a framework to design PD programs.

Our PD program offers a range in grade levels (K-12) and duration from two hours to one week. Included are lectures, hands-on activities, connections to standards-based teaching, and workforce issues. We stress the interdisciplinary nature of NSE. Many of our workshops occur at local, regional, and national science teacher conferences where we introduce participants to a variety of teaching modules and resources. The shorter duration workshops do not allow for follow-up activities as prescribed by PD models except we do reach participants with newsletters and surveys. Week-long workshops provide us the opportunity for more in-depth training and additional follow-up activities. Our approach has been and will continue to be - helping teachers see the importance of NSE in science education and how it can fit into a standards-based curriculum. We have been able to reach teachers in 44 of the 50 states.

1.3 Program Development

As we began to develop our PD program we asked three questions: 1. What NSE concepts should be included? 2. How do these concepts relate to K-12 science content? and 3. Do the approaches used lead to correct understanding of key concepts? The first step in the process was to determine teacher needs. We conducted surveys in 2005 and 2006 with the results shown in Table 1.

TABLE 1. Survey results of teachers on resources needed to include NSE in teaching.

Question	Choices and Responses				
NSE Knowledge	None	A little	Some	A lot	
	15%	50%	31%	4%	
Source of NSE Knowledge	News media /publications	Colleagues	Internet	Workshop	Students
	49%	14%	7%	14%	16%
Type of materials	Add-on unit (enrichment)	Short activity-required concept(1 class)	Special topic linked to NSE (2-3 weeks)	Required concept & NSE (2-3 weeks)	Other
	15%	46%	12%	25%	2%
Support needed to include in class	Textbook/printed materials	Online units	Videos	Workshops	Online help
	8%	30%	14%	30%	18%

From these results, we ascertained that teachers knew little about NSE and that they would prefer lessons tied to required concepts (state/national standards). With this information, we began to plan our PD program.

The first issue that we needed to address is that NSE is not directly included in state or national standards. Benchmarks 2061 has some NSE standards such as 8B – The Designing World – Materials and Manufacturing which states: "Objects made up of a small number of atoms may exhibit different properties than macroscopic objects made up of the same kinds of atoms."[23] In contrast, the National Science Education Content standards (NSES) for Properties and Changes in Matter states: "A substance has characteristic properties, such as density, a boiling point, and solubility, all of which are independent of the amount of the sample." [24]We approached this disconnect by linking each lesson to the Big Ideas as well as content standards (national or state) as shown in the example in Table 2.

TABLE 2. Connections of Big Ideas, size and scale lessons, and National Science Education Standards.

Big Ideas	Nano-lesson	Standards
Structure of mater	Size and Scale Cards	**NSES - Standard B Physical Science - Properties and changes** of properties in matter (5-8)
Forces & interactions		
Self-assembly		
Size & scale		NSES - Standard B Physical Science - Structure and properties of matter (9-12)
Size dependent properties	Surface Area to Volume Blocks lesson	
Quantum effects		2061 - The Mathematical World – Numbers 9A; Habits of Mind 12B (6-8)
Tools & instrumentation		
Models & simulations	Movement of NaOH into Agar blocks lesson	2061 - The Mathematical World – Numbers 9A; Common Themes – Scale 11D (9-12)
Science & technology		

For our initial workshops, we assessed approximately 50 lessons available on the web. The requirement for use in the workshops included: good science content, aligned with science concepts required by state standards, were not complicated, used inexpensive materials, and were of short duration (1-3 class periods). Typical lessons addressed size and scale, self-assembly, and hydrophobic/hydrophilic properties. We always include a lesson on size and scale as it is important to understand the size of the nanoscale, especially in relation to macro and micro worlds. Pre and post results for size and scale lessons are presented in Table 3. The good news is that most teachers know the size of a nanometer and this result has been consistent for several years of workshops. However, teachers have a difficult time in sorting different size objects (a size sorting activity with various sized images). [25]-[26]

TABLE 3. Teacher responses pre and post on size related questions.

Lesson	N=85	
1. Size of a nanometer	Pre	Post
Correct	89%	99%
Incorrect	11%	1%
2. Size sorting: macro to nanoscale		
Correct	64%	69%
Incorrect	36%	31%

Work with 21 teachers in the NanoTeach PD project stresses the importance of including size and scale activities with students before moving on to other nano-focused lessons. All of the teacher participants began their year-long introduction of NSE topics with their students by using size and scale lessons and recommended this approach as a necessary sequence for students to understand nanoscale concepts [27].

We learned early on that it is important to present nanoscale lessons in clear and precise language and to phrase assessment questions in exact terms. For example, we presented self-assembly as one method of nanofabrication. In reviewing the pre and post survey results for workshops between 2007-2009, we discovered that in the pre-survey 37% correctly answered the question and only 33% in the post-survey. In discussions with participants, they indicated that the hands-on self-assembly activity indicated to them that this method as the only form of nanofabrication. We changed the lesson to include a Lego® representation of top down nanofabrication. Pre and post survey results were much better with 54% correct in the pre and 70% in the post. In 2009, we refined our workshops based on evaluation results, particularly in reference to teacher learning. It appeared to us that teachers seem to "remember" the topic of the activity but often did not grasp the underlying principle they should learn. This indicated that we had to place more emphasis on the major concepts we wanted them to understand. In prior workshops we demonstrated Atomic Force Microscopy (Big Idea – Tools and Instrumentation) but what teachers did not understand was why we needed such instrumentation. We then changed our introduction to the lesson to include more information concerning wavelengths of light and where nanoscale objects fall in relation to visible spectrum. With this change, we saw improvement in understanding with 86% correctly answering the question regarding the use of AFMs compared to 10% for the original introduction.

Most of the results presented herein have been for short workshops where we introduce several topics, dependent upon the workshop's duration. In 2009, we provided a one-week workshop to middle and high school teachers in a rural part of Georgia. These teachers were also required to teach a summer camp to secondary students in their school district. The purpose of the camp was to provide teachers a venue to enact what they had learned, determine where they had concerns, have these concerns addressed, and develop confidence to use the materials in their classroom. We also developed a assessment instrument which included 25 content-based questions. While only 7 teachers participated, the results are similar to ones for our shorter workshops in terms of content learning.

TABLE 4. Sample of pre/post workshop responses to content questions.

Question	N = 7	
1. Size of a nanometer	Pre	Post
Correct	50%	100%
Incorrect	50%	0%
2. Property of matter stays constant between macro & nanoscale		
Correct	64%	69%
Incorrect	36%	31%
3. Which has the largest surface area-volume ratio (image choice)		
Correct	86%	100%
Incorrect	14%	0%
4. Ferrofluid is a (list of choices)		
Correct	43%	43%
Incorrect	57%	57%

Overall, the participants showed an increase in content knowledge. They had difficulty understanding the nature of ferrofluids and the role of gravitational and electromagnetic forces at macro and nanoscales. However, they knew the content well enough to improve the content knowledge of the camp participants (Table 5).

TABLE 5. Assessment results of student content knowledge (nano and general science) from NSE camps.

Domain	# of items	Mean score		Change pre-post	% actual/ potential
		Pre	Post		
Nanoscale	12	39.5	62.0	22.5	37.2
Science content	13	37.9	84.4	46.4	74.8
All	25	38.7	73.6	34.9	57.0

While the majority of our workshops have been short duration with no follow-up activities, we were curious to learn if participants were using the resources we shared with them. While only 36 of several hundred participants have responded the results are positive and were consistent over the course of the collection period (Table 6). We are currently re-issuing the call to increase the number of responses.

TABLE 6. Follow-up survey results from PD participants.

Did you use the workshop resources?	
Used a lesson from workshop	42%
Used more than one lesson from workshop	42%
Used a lesson from another source	5%
Did not use any nano lessons	11%
How did you use workshop resources?*	
As part of a state-standard based lesson; short activity & required concept	61%
Special nano topic – short activity not required concept	33%
Special topic – longer activity	11%
Did not use	8%
*Includes multiple answers	

1.3 Conclusions

We have learned several things from our NSE PD program. We know that misconceptions of concepts may be tied to too many topics in a short time frame and topics introduced must be clearly presented and include very specific concept information. Our longer workshops provide for greater depth of understanding of key NSE concepts. We reduced the number of lessons in shorter duration workshops to enhance content knowledge. Careful attention must be paid to ensure teachers correctly incorporate NSE into their knowledge base. The assessment results indicate that both teachers and students can improve their content knowledge of not only NSE concepts but also general science concepts. There is a need for NSE PD as evidenced in participation in our workshops which has steadily grown from ~ six per workshop to now >50 per workshop. Tying the NSE concepts into standards-based teaching is the key to including nanotechnology in the K-12 curriculum.

2 ACKNOWLEDGEMENTS

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179 DEVELOPING GLOBALLY AWARE SCIENTISTS AND ENGINEERS IN NANOSCALE SCIENCE AND ENGINEERING

Nancy Healy[1] & Lynn Rathbun[2]

1 Georgia Institute of Technology and the National Nanotechnology Infrastructure Network, Atlanta, GA, USA, nancy.healy@mirc.gatech.edu
2 Cornell University and the National Nanotechnology Infrastructure Network, Ithaca, NY, USA, rathbun@cnf.cornell.edu

ABSTRACT

The National Nanotechnology Infrastructure Network (NNIN) is a NSF-funded program which supports nanoscience researchers by providing state-of-the-art facilities and resources at 14 U.S. universities. (http://www.nnin.org). The NNIN has an education and outreach program with one of its goals to encourage and develop talented students (undergraduate and graduate students) to become future leaders in nanoscale science and engineering (NSE). We have developed and implemented three programs that we hope will lead to globally aware scientists. In 2007, we established the NNIN international Research Experience for Undergraduates program (iREU). NNIN established this program because we believe that globally aware scientists and engineers should be a priority in the 21st century. Undergraduates spend 10-11 weeks at facilities in Japan, Germany, Belgium, The Netherlands and France. The second program is a graduate level program with our Japanese partners at National Institute for Material Science (NIMS). NNIN sites host a number of graduate students from Japan's Nanotechnology Network (Nanonet), which is managed by NIMS. The goal of this summer program is much the same as the iREU, that is, to increase awareness of the global nature of research for both the visiting Japanese and the host NNIN sites. The final "global" program is the international Winter Schools for Graduate Students (iWSG) which are organized jointly by NNIN and institutions in developing countries with the goal of promoting international bridge building and understanding by bringing together students and faculty in an intense teaching and societal experience.

Keywords: Nanoscale science and engineering, undergraduate education, graduate education

1 INTRODUCTION

Thomas Friedman's book The World is Flat, drew attention to the "flattening of the world" in the twenty-first century and how this "flattening" will greatly impact countries, societies, governments, and companies.[1] These global linkages present new challenges as well as opportunities for educating engineering students. Much of the linkages that are and will occur are due to advances in technology with a major role being played by engineers. This in turn makes for new approaches for "doing" engineering, in particular acquiring a global perspective which includes an understanding of the different approaches to problem solving. Students should also develop knowledge about the complexities of the global environment and its social implications. One study indicated that students' exposure to global perspective should include how to "work effectively with people who define problems differently."[2] The U.S. economy is based on innovation and new technologies both of which have felt the effects of globalization. A recent report indicates that the U.S. must commit to embracing the global economy and train its workforce to be competitive in the global marketplace.[3] Many engineering programs are including global components in their curriculum to face this challenge. We report here on approaches to develop a global understanding of nanoscale science and engineering (NSE) by immersing undergraduate and graduate students in research and/or courses in European countries, Japan, and developing nations. We have developed three international programs to provide undergraduates and graduate students experiences in a variety of global settings. These programs include variations and mixing of the four of the five typologies that can be used to achieve global competency by engineering students: international enrollment, international project, international work placement, and international field trip.[2]

The importance of global education is recognized by the National Science Foundation (NSF) by its development of several programs focused on global placements. NSF stresses in its publications and programs the importance of supporting U.S. scientists and engineers to develop international collaborations that will help ensure that they gain international experience particularly early in their careers.[4] NSF has an entire division, Office of International Science and Engineering that supports the development of scientists and engineers who will become leaders in international collaborations that NSF sees as key to U.S. development and its role as a world leader in science and technology. The National Academy of Engineering also stresses the importance of a global perspective and in one study notes the recent major expansion of the STEM research workforce in the world.[5]-[6] There has been a 35 percent increase in the U.S. and Europe research workforce and 50 percent in China. This increase has been attributed to the fostering of networks and collaborations across global boundaries through technology and is expected to have major implications for engineering in the future.[6] The National Science Board has also recognized that one of the key challenges facing engineering is how do U.S. programs respond to the changing global context of engineering, technology and science. [7]

1.1 The National Nanotechnology Infrastructure Network – Education and Outreach Programs

The National Nanotechnology Infrastructure Network (NNIN) is a NSF-funded program which supports nanoscience researchers by providing state-of-the-art facilities, support, and resources. The NNIN is an integrated partnership of fourteen U.S. universities (http://www.nnin.org) which provide user support and resources for NSE researches. We also have a networked education agenda which offers a variety of programs for school-age children through adult professionals. One of our goals is to educate a dynamic workforce, one ready for the challenges of not only NSE but also the globalization of the world's economy. Towards this goal, we instituted three programs focused on international experiences for undergraduate and graduate students.

1.2 International Research Experience for Undergraduates (iREU)

The purpose of this program is to promote development of globally aware scientists by exposing promising young scientists, in this case talented undergraduates, to the promises and challenges of research in an international environment. We aim to demonstrate to these participants that not only is research in the global context a necessity in the 21st century, but it is also both exciting and well within their capabilities. By providing this opportunity early in their careers, we hope to have maximum long term impact. To this end, we have structured a program which selects the most promising candidates from a pool of already select students, have partnered with leading international nanotechnology research laboratories, and have provided the necessary support structure to make the experience challenging and rewarding. Our international partners include: National Institute for Materials Science in Tsukuba, Japan, the Forshungszentrum Julich in Germany, IMEC in Belgium, Delft University of Technology in The Netherlands, and Ecole Nationale Supérieure des Mines de Saint Etienne in France. We place approximately 16 students each summer.

This program builds upon the successful NNIN Research Experience for Undergraduates program (REU) which annually hosts approximately 80 students in an introductory nanotechnology research program at the 14 NNIN sites.[8] The NNIN REU program is used as a feeder and filter program for the iREU program, which is held in the "2nd summer", the summer after the initial REU experience. Only students who have successfully completed the prior summer NNIN REU program are eligible to apply for the next summer iREU program. This limitation assures that the students have a good level of basic laboratory expertise in NSE and can thus make the best of the international research opportunity offered to them.

Participants are selected using a variety of criteria: the application with several written statements, his/her written REU project report, the video of the presentation at the REU convocation (end of summer meeting),[8] and the evaluations of the NNIN REU site coordinator, the REU project faculty member, and REU project graduate student/post-doc mentor. Of these, the evaluation by the host faculty member is the most critical in selecting those students who can best represent NNIN and who would most benefit from the program. Our ability to select only the most advanced and mature students is critical to the cooperation we receive from our partners.

Each selected student is paired with a project host or a senior staff scientist. Students are assigned to projects within their area of interest and consistent with their prior research experience. On a daily basis, the students generally interact with a post-doctoral researcher or graduate student, with regular significant interaction with the senior staff host. The students spend 10-11 weeks at the host institution and become fully immersed in the research group and the research culture. Projects tend to be at a level higher than the prior summer's research project thereby building on their skill set. The placement settings not only have researches from the host country but more often from several other countries which provides a truly international perspective to research ideas and approaches.

This program provides an excellent career growth opportunity for the participants. iREU interns have indicated that their prior NNIN REU experience allowed them to meet the challenges of a more advanced project, work in a different research environment, and live and work with colleagues from other cultures. Of the 52 participants in the 4 years of this program, 26 are in graduate school and 13 are still undergraduates; the remainders are employed but some of them intend to return to graduate school. The 26 in graduate school include 5 NSF fellows, a testament to the high quality of the participants and the boost that participation in this program offers. In 2011, we undertook a follow-up survey of all of the participants with 46 of the 52 responding. Table 1 summarizes the results of the iREU follow-up survey. The results clearly demonstrate the positive impact this program has on the participants.

TABLE 1. Results of post-survey of iREU participants 2008-2011.

Question iREU follow-up survey 2011 n=46	Avg.
My REU experience was important in securing my current position (grad school, work) or in	4.5
The program helped me feel confident to work in an international setting	4.8
The program helped me feel confident to work with international colleagues	4.8
The program helped me develop relationsips with international researchers and colleagues	4.6
The program helped me understand the global nature of science and engineering	4.6
The program helped me to develop an interest in working internationally	4.5
I consider my participation to have a positive influence on my future educational or career choices	4.9
The porgram helped me to develop a global perspective regarding research and society	4.8

Likert Scale 1-5: *1 = poor/no 5= superior/very yes*

1.3 International Research Experience for Graduate Students (iREG)

As an integral part of our relationship with NIMS Japan for hosting our iREU program, NNIN hosts a number of graduate students from Nanonet, the Japanese equivalent of NNIN, which is managed by NIMS. The goal of the iREG program is much the same as iREU, that is, to increase awareness of the global nature of research. Approximately 5 Nanonet graduate students come to the U.S. each year to conduct research in faculty labs. NNIN solicits a group of projects from the NNIN sites suitable for graduate level research. Nanonet students complete an application and make a ranked selection of projects that they would like to collaborate on. NNIN management staff then match students to projects. The projects provide enough variety of choices so that the participants are matched with research programs that complement and enhance their area of interest.

Each of these students is at the NNIN site for 8-10 weeks during the summer at which time they are treated much like our REU students. In particular, they are integrated both socially and technically with the REU students, which adds greatly to their research and cultural experiences. Unlike undergraduate REU students, these graduate students come with a significant prior skill set and more focused scientific interests. During this time they integrate into the appropriate faculty research group, are trained in equipment and techniques, and contribute to both their own research project and the overall goals of the research group.

Since 2008, 18 students have been hosted at eight NNIN sites. NIMS has indicated that they are extremely pleased with the interactions their students receive from the U.S. hosts. NNIN sites indicate that the REU interactions with the Japanese students provide an excellent, and often, first global connection with an international researcher. This also has inspired our REU students to apply for the iREU program for the following summer so that they may continue their development as global engineers and scientists.

1.4 International Winter School for Graduate Students (iWSG)

The international Winter Schools for Graduate Students (iWSG) are organized jointly by NNIN and institutions in developing countries with the goal of promoting international bridge-building and understanding by bringing together students and faculty in an intense teaching and societal experience. The objectives are to place nanoscience in the context of the developing world and demonstrate the societal and ethical dimensions of nanotechnology. In addition, we hope to establish relationships with foreign researchers while providing an intense course on select NSE topics.

Each year, approximately 10-15 U.S. graduate students and 5-7 U.S. faculty participate in a rigorous course in an emerging and research-intensive interdisciplinary NSE topic at a host institution in a developing country. Host country faculty also participate in the course offering. This course lasts six days and includes laboratory sections. The course is followed by travel to a rural, underdeveloped part of the country (~4-5 days) where students spend time observing, experiencing and discussing the societal challenges and the role science and technology can play in a developing society. A large group of students from the host country participate in the course part and a smaller group joins in the rural experience. These two components of the course allow for interactions among the student groups. The winter school is a comprehensive education program whose content is archived at the NNIN education portal. See, e.g. http://www.nnin.org/nnin_grads.html for complete access to course materials.

U.S. students are selected from across the country and do not have to be from an NNIN site for consideration for participation. Approximately 45 applications are received annual from our call for participation to departments across the country. Each applicant completes an online application which includes written responses and faculty recommendations. We seek students with strong academic backgrounds, an interest in societal issues related to technology, and who have the potential to become leaders in their filed.

The program began in 2008 with the four courses at the following sites:

- IIT Kanpur, India: Organic Electronics -12/2008
- IIT Mumbai, India: Nanoelectronics - 12/2009
- IISc Bangalore, India: Nanofabrication - 1/2011
- University at Campinas, Brazil: Silicon and III-V Nano Photonics Campinas, Brazil - 1/2012

US students complete an evaluation instrument for each of the iWSGs and the results are too voluminous to be presented in this paper. Overall, the courses receive very good ratings including providing a broad perspective to the targeted field and its challenges as well as allowing participants to interact across international boundaries and see other world perspectives. This latter was an important goal of the program in that we are seeking to develop globally aware scientist through this experience, an important focus of the program.

Participants in the field trip portion of the trip complete an essay on their thoughts and observations. These essays indicate that students are extremely positive about the workshop and the field trip. The visits to rural villages in India were "eye-opening" events for all participants and helped them to see how technology connects and potentially can help the poorest people in the world. Sample comments by the US participants are below and these examples indicate the cultural impact of the global experience:

- "I didn't expect to see such a big diversity in the population here; Brazil seems to have drawn immigrants from many different countries."
- "I really enjoyed the chance to interact with the Brazilian grad students during the first week; I learned that while some of them are very confident in their English-speaking skills, others struggle."
- "A Brazilian student shared his perspective that his interaction with our group has erased some of the prejudices he had about Americans. We agreed that prejudices on both sides were broken down by the two week experience."
- "While we've routinely interact with graduate students from developing nations (e.g. China, India, Turkey), we've noted that we rarely get to interact with Brazilian students. For that reason, the ability to network with so many Brazilian students (an opportunity we rarely get at conferences, even those that are international) was a transformative experience."
- "From the trip to the rural area in India, I learned that we, as engineers and scientists, must share the responsibility of increasing people's quality of life in rural areas. The reason is that we do have the infrastructure and knowledge needed to investigate solutions to daily problems (and people from villages do not….. The iWSG provided an excellent experience in understanding people's lives in rural areas and in making us aware of our role in the quality of life of society in general."

In fall 2011, we instituted a new survey to follow-up with participants to gain information on how they perceived the technical and societal portions of the course years to months after their participation. To date, 24 of the 33 participants (from the first 3 years) have completed the survey. This survey will become ongoing and will be administered annually several months after participation in the iWSG. Results for the technical and societal pieces of the survey are presented in Table 3. The results demonstrate that the technical portion of the course does an effective job in presenting the technical aspects and that the topics have been at the forefront of new knowledge. The societal portion of the program received very high marks and clearly demonstrates that exposure to the underdeveloped world is extremely important in developing a global perspective in these young scientists and engineers. Ninety percent of the respondents indicated that the iWSG was time well spent in their academic career and 68% indicated that the experience has had an impact on their views of technology and society.

TABLE 3. Follow-up survey results of iWSG participants 2008-2011. Results are for the technical and societal portions of the iWSG.

Technical Portion Questions iWSG 2011* (participants from IWSG 1,2,3)	Avg.
The course was the correct level for my background and experience	3.6
The presenters were very knowledgeable and added to my understanding of the topic	4.5
The course provided the right balance of lecture, labs, and discussion	3.4
The course provided the host country's perspective on the topic	4.0
The course provided an effective forum to discuss critical technical issues	3.3
The course duration was sufficient for the topics covered	4.2
The course topic was timely and provided current and cutting-edge information	4.3
Societal Portion Questions iWSG 2011*(participants from IWSG 1,2,3)	Avg.
It allowed me to identify/perceive the world context of technology	4.7
It allowed me to see how technology can help improve the lives of under-served populations	4.6
It allowed me to put my research in the context of the global arena	4.1
It allowed me to have discussions with the foreign participants about technology and society	4.8
It opened up my understanding of technology and the impact on society	4.6
It has influenced my future in terms of my career choices	4.1

*Likert scale 1-5 1 = poor/no 5 = superior/very yes

2 CONCLUSION

The NNIN has developed three distinct programs to encourage the development of globally aware undergraduate and graduate students. We have been fortunate to have excellent foreign partners who fully support these programs and their continued development. For the iREU program, the students are place at facilities that typically support post-doctoral or graduate student level international researchers. Placement of undergraduate researchers in these facilities has been new yet our hosts have been quite pleased with the ability of the students that have participated and in the amount they have been able to accomplish in a short period. Survey results indicate that the experiences of the undergraduates have achieved the goal of developing a global awareness of NSE research. The iREG program has provided a venue for Japanese students to experience the U.S. approach to research but also allows our U.S. hosts and students to gain a perspective on the Japanese culture. Success of this program is the continued support of Nanonet to fund its students' participation. Lastly, the iWSG has had a significant impact on U.S. participants especially with regards to the societal dimensions of the program. Creating such opportunities for both academic and cultural exchange of ideas will play an important role in the development of future STEM leaders.

3 ACKNOWLEDGEMENTS

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184 ASSESSMENT OF STUDENTS PROJECT – NUMBERS, LETTERS, WORDS

L. B. Kofoed[1] & M. S. Stachowicz[2]

1 Department of Architecture, Design & Media Technology, Aalborg University, Denmark. lk@create.aau.dk

2 Laboratory for Intelligent Systems, Department of Electrical and Computer Engineering, University of Minnesota, USA, The Warsaw School of Computer Science, Warsaw, Poland. mstachow@d.umn.edu

ABSTRACT

The evaluation and assessment of engineering programmes is a big issue, and there exist many concepts and methods. This paper deals with the assessment methods which can be used when assessing the knowledge, skills and competences developed in projects using PBL (problem based and project organized learning) pedagogical approaches. The experience of assessing first year projects from the Medialogy education at Aalborg University and third year projects from the Electrical and Computer Engineering Department at University of Minnesota, Duluth are presented, and the different methods discussed. The conclusion is that process as well as product has to be assessed in a way which evaluates all aspects of students' learning outcomes.

Keywords: Assessment, PBL, project work, Medialogy, electrical engineering.

1 INTRODUCTION

New engineering programmes are being developed to meet the requirements of society and industry. Specific knowledge, skills and attitudes are needed if industry is to stay innovative and competitive in a global world. As a consequence, while engineering education has been innovating in the area of emerging disciplinary and interdisciplinary knowledge, research and technologies, as well as in new pedagogical approaches to meet the needs, it is still lacking useful assessment and evaluation methods [1]. The evaluation of engineering programmes has been on the agenda for several decades, and the amount of literature dealing with different evaluation approaches shows that there are many useful concepts and methods [2]. The problem we have experienced is the lack of assessment methods which can be used when assessing the knowledge, skills and competences developed in projects using PBL (problem based and project organized learning) pedagogical approaches [3]. These projects are very complex to assess because each project is unique. This is a huge challenge that involves many resources for the teachers who are going to assess the projects, because the content of the different projects often requires different assessment criteria, which still have to be consistent with the learning goal of the official study regulation or learning module. A number of different assessment methods are available for project work which can be used for the assessment of a range of different skills, and for its evaluation, either formative or summative, by different assessors. These assessment approaches take account of different outcomes of the learning: technical knowledge, problem-solving, communication, teamwork, independent learning, and so on [4]. It is important for the teachers assessing the projects to have the necessary tools for assessment.

In this paper we will introduce the Danish and American grading scale, and then present the experience from two cases: the assessment of first year projects from the Medialogy education course, Aalborg University (AAU) [5], and third year projects from the Electrical and Computer Engineering Department at University of Minnesota Duluth (UMD) [6] The assessment methods used in the two cases are discussed. Furthermore students' expectations and teachers' experience of the methods used for assessing the projects are presented.

2 THE GRADING SCALES

In the academic year 2005–6 Denmark introduced a new scale, 7-trins-skalaen (7-step-scale; colloquially dubbed the 12-scale), designed to be compatible with the ECTS grading scale. The Ministry of Education also wanted to adopt a more international way of grading, by allocation a set number of grades because in foreign countries, the grade A (12) is handed out twice as often as it is handed out in Denmark [6]. The scales are set out in Table 1.

TABLE 1. The Danish, the ECTS and the American grading scale [7].

Definition	Excellent		Very Good	Good		Satisfactory	Passed	Failed		
7-point scale	12	12	10	7	7	4	02	00	00	−3
ECTS scale	A	A	B	C	C	D	E	FX	FX	F
American scale (4.0)	A+	A−	B+	B	B−	C+	C	F	F	F
American scale (4.3)	A+	A	A−	B+	B	B−	C	F	F	F
American scale (4.5)	A+	A+	A	B+	B+	B	C+	F	F	F

The definitions of the respective grades are as follows:

Grade 12 (A, A–) should be awarded for an excellent performance displaying a high level of command of all aspects of the relevant material, with no or only a few minor weaknesses.
Grade 10 (B+, B–) should be awarded for a very good performance displaying a high level of command of most aspects of the relevant material, with only minor weaknesses.
Grade 7 (B, B–) should be awarded for a good performance displaying good command of the relevant material, but also some weaknesses.
Grade 4 (C+, C–) should be awarded for a fair performance displaying some command of the relevant material, but also some major weaknesses.
Grade 02 (C–, C+) should be awarded for a performance meeting only the minimum requirements for acceptance.
Grade 00 (F) should be awarded for a performance which does not meet the minimum requirements for acceptance.
Grade –3 (F) should be awarded for a performance which is unacceptable in all respects.
The grading scale is clear, and it is possible for students to compare their results in an international environment, but giving students useful feedback on their projects is difficult.

Then the performance against the official goals has to be used as the basis for providing feed-back.

3 GRADING STUDENT PROJECTS

Case: Medialogy first year, AAU

Aalborg University's engineering and science programmes are structured in modules and organized as PBL studies. A module is a programme element which aims to give the students a set of professional skills within a fixed timeframe specified in ECTS credits, and concluding with one or more examinations within a specific exam period. The programme consists of lectures, classroom instruction, project work, workshops, exercises, and so on. In Table 2 the different modules of the Medialogy programme are shown.

Each semester has a theme which provides the framework for a student's semester project. Students form a project group of five to seven persons, and this group has to complete the project according to the goals set out in the study regulation. All modules are assessed by individual grading, which is according to the 7-point scale or Pass/Fail. The theme for the first semester is: designing from both sides of the screen. The semester has five modules and the project represents one third of the semester.

TABLE 2. Overview of Medialogy – the first semester modules.

Semester	Module	ECTS	Assessment	Exam	Type
1st	Creative Play – Applied Technology	5	Pass/Fail	Internal	Mandatory
1st	Designing from Both Sides of the Screen (Semester project)	10	7-point scale	Internal	Mandatory
1st	Animation and Graphic design	5	7-point scale	Internal	Mandatory
1st	Problem Based Learning in Science, technology and Society	5	Pass/Fail	Internal	Mandatory
1st	Introduction to Programming	5	7-point scale	Internal	Mandatory

The objectives of the first semester project are: "To provide the student with practical experience of defining a project within the area of IT, communication and new media, which includes use of object-oriented programming, to implement the project by working in groups and to document the solution in a project report" [8]. Further qualification goals for students who complete the project module are listed under knowledge, skills and competences. The qualification goals are related to Blooms Taxonomy [9].

Knowledge qualifications include, for instance, understanding how an object oriented programming language can be used to solve a specific problem; knowledge of commonly occurring data structures, algorithms and abstract data types and their application; the understanding of problem-based study and the Aalborg PBL model; and, knowledge of project management in a long-term problem based project (in this case from two to three months).

Skill qualifications include, for instance, the ability to apply media oriented methods and tools in the design and implementation of interactive media oriented projects; the ability to describe the theory, methods and practices of media oriented projects regarding a chosen technology, context and target group (analysis); the ability to discuss, argue, analyse and synthesize theory, methods and practices in media oriented projects, especially related to specific semester courses; and the ability to analyse individual as well as organizational learning processes by scientifically recognized concepts and methods (application).

Competence qualifications include, for instance, using object oriented programming in solving programming tasks related to Medialogy, communication and IT/new media (application).

The exam is an individual oral examination, and is based on a written report, a media-technological product and an audiovisual (AV) production that illustrates and summarizes the project, plus a written process analysis. The assessment is performed in accordance with the 7-point grading scale (see Table 1).

The exam starts with the group's presentation of their project, which must not influence the individual examination. In practice, before the examination, the censor (assessor) and the supervisor decide the level of the project and consider the problems in the report which should be discussed at the individual examination. After the examination the individual student in a group is given a grade. The project group very often get the same grade but sometimes there is a difference, which may be small or large (see Table 3).

TABLE 3. The groups and the individual group members' grades.

Group	Grades		Group	Grades
A	10 – 10 – 10 – 10		L	12 – 12 – 12 – 12 – 12 – 12
B	7 – 7 – 7 – 7 – 7 – 7		M	7 – 7 – 7
C	7 – 7 – 7– 7		N	7 – 12 – 10 – 12 – 10 – 7 – 4
D	7 – 02 – 02 – 7 – 02 – 7		O	4 – 02 – 02 – 02 – 4 – 4
E	7 – 4 – 7 – 7 – 10 – 4 – 7		P	7 – 4 – 4 – 10 – 10 – 02
F	7 – 7 – 7 – 7 – 7 – 7 – 7		Q	7 – 10 – 4 – 4 – 10 – 7 – 7
G	4 – 7 – 7 – 4 – 7		R	7 – 7- 4 – 02 – 02 – 10
H	10 – 7 – 10 – 10 – 7 – 7 – 7		S	4 – 4 – 4 – 4 – 4 – 4
I	10 – 12 – 12 – 10 – 10 – 12		T	10 – 10 – 10 – 10 – 10 – 10
J	7 – 7 - 7 – 7 – 7		U	10 – 10 – 10 – 7 – 10
K	4 – 4 – 4 – 7 – 7 – 4			

As Table 3 shows, students in the same group do not necessarily get the same grade, and there might even be a big difference between the individual grades. However, the project is a common product which is the basis for the examination and for the final grade. So when a project is graded at 7 some students might raise their grade by one or two levels, and of course also lower their grade by a similar amount. However, the gap is very seldom more than two or three points.

The final result does not cover the project process and the performance as well as the results obtained during the project work; this is because it is not possible to grade the process of learning, only the results of the learning. The individual presentations often differ so much that it is difficult within the time frame to give proper feedback which covers both the project and the individual examination result.

Case 2: The third year ECE design workshop, UMD

The Electrical and Computer Engineering (ECE) design workshop topic involves the use of fuzzy logic to control comfort in solar homes [6]. In the workshop, students work in pairs, and are required to design, build and program a controller with intelligent behaviours using fuzzy logic. The project work is carried out according PBL principles [3]. This pedagogical approach implies that the students, within a theme, choose for their projects a problem they want to investigate and solve. In the 15 week workshop no formal lectures are provided; however, the students receive an intensive review covering the topics of the 68HC12 microcontroller, sensors, and fuzzy logic control. Since no formal lectures are taught in this workshop, an intensive review covering important material related to the specific topic is provided at the beginning of the semester. For the robotics and intelligent systems topics, the reviewed material includes the following: the MC68HC12 architecture and assembly language; an introduction to robotics, sensors for robotic applications, motors and drivers; and fuzzy logic. It is important to bear in mind that since this is a capstone design, students should be able to apply the knowledge and skills that they have learned on previous courses to solve problems that will emerge during the development of the project. This means that the students have to show the ability to use, combine and generalize knowledge gained previously in a new situation. Furthermore, the students have to organize how they work, contribute to their project, and set up detailed work plans.

In 2010 the ECE workshops had twenty students and two advisors/teachers. Pairs of students were formed and each pair was encouraged to develop ideas of their own and present a proposal for their project. All the proposed projects had to fit into the selected topic, and be reviewed and approved by the instructors. The students had 15 weeks to do all the work, from the initial definition to the development and completion of the project. The goal is that students should obtain specific technical knowledge according to the study programme as well as knowledge of group work, project management and communication skills. Students have to

- Complete a design project that is interdisciplinary in nature, integrating the knowledge obtained in previous ECE classes.
- Accurately communicate their project results, both in written report format and though oral presentation.
- Understand how teams work and how to interact in a team setting (including, understand what it is like to work in industry).
- Appreciate the role of engineering in society, and ethical issues.

The projects are evaluated in several stages, in both a gradual and continuous way. In the weekly meetings each pair presents progress on the evolution of their projects and receives guidance from their teachers. The objectives of these weekly meetings are also to closely observe each group's progress and ensure that each group member is contributing to the project work. For the final grade, each member of a project pair obtains the same grade: 35% was assigned during week nine, when students presented a written report and an oral presentation of the results of their simulations; 35% was assigned to the students during week 15, when they demonstrated that their project is working in accordance with the specifications; and, the final 30% was assigned on the basis of the quality and clarity of the final oral presentation, the completeness of the final written report, and the quality of the poster.

The process competences are closely connected to the project work in general, and it is expected that the students' performance reflects what it takes to carry out project work in a group. The students get feedback during the project about the project's progress, and the relatively small numbers of students and teachers make it possible for the teachers to develop a profound knowledge of the standing of the groups with regard to the technical as well as the process competences. By the time of the final examination the groups have a strong impression of the quality of their project as well as of their processes, which is furthermore confirmed by the final examination and feedback.

4 THE CHALLENGE OF GIVING USEFUL FEEDBACK ON STUDENT PROJECTS

In the Aalborg case the students are individually assessed according to the results of the project and the knowledge they show during the examination, even though the project work in groups plays an important part of how they have reached their goal in the project. The teachers have weekly meetings with the groups, and are very aware of the learning process. Several milestones are put in place to follow the work and progress of all the project groups. The milestones include mid-term seminars, design briefs, and so on, where students present the actual situation and status of their project. Furthermore, the teachers have a common meeting after the students hand in their projects to discuss how to grade them. The projects from previous years are used as guidelines, but even after this discussions teachers often find it difficult to give grades according to the study regulation, as the many different dimensions related to knowledge, skills and competences make the grading complex.

Interviews with the teachers show that they use different methods to assess the project before the individual examination. They assess each dimension and then sum up with a final decision about the project grade. As part of assessment preparation, teachers assess the same projects and compare the results of their grading. It is interesting to note that even when using different methods, the teachers grades were the same for 90% of the projects, so the basis for the assessment of the individual project is quite solid regarding the point on the grading scale. When it comes to the assessment of the individual oral exam, the teachers' approach is different. Some teachers base questions on the three dimensions in the study regulation, which the students can draw from a box; and some teachers have a number of questions related to different aspects of the report. All teachers state that it takes a long time to devise good questions as they have to prepare the questions for each report, and the reports are very different as students can chose which problems they want to solve in their projects.

All teachers say that they find it very difficult to give feedback in situations where individual grades differ by more than two points, as the grade for the project count for all students in the group;and all teachers state that it is very important for them to give immediate feedback to the individual student and to explain why the individual grade was given. Students appreciate the feedback and would like the process competences to be part of their exam results in a way that their future employers would understand. Another element of this process that teachers find difficult is that they know each student's work performance during the project, but they cannot make use of this knowledge, as the results are based on the final project and the individual performance in the examination.

The UMD case shows that, with only two members in each group, it is easier to provide specific feedback to students. The assessment of the process is combined with a final assessment. The assessment of the projects is usually provided in terms of normal descriptive language, since the projects are too complex for a numerical assessment, and according to the teachers, is unacceptable. For example, when grading a final written report an assessment is based on several perspectives such as creativity, style, grammar, and so forth, and the final grade for the project is based on descriptors such as excellent, very good, good, fair, poor, and unsatisfactory, rather than on a numeric measure. The process of determining a grade for a specific report is seen as equivalent to the process of determining the membership of each of the evaluation categories, and this process is implemented through the composition operation [10].

5 CONCLUSION AND DISCUSSION

In both the AAU and UMD cases different assessment methods are used. The AAU assessment purpose is to give a final judgment of the project together with an oral examination performance in topics related to the project, and it is based on a numeric grading scale. The UMD assessment is based on formative as well as summative purposes. The purpose of the UMD assessment is to give a final judgment of the process and the project, and together with an oral presentation the result is given by means of a descriptor representing categories on a scale.

The study shows that several assessment methods are in use in both cases with more or less emphasis on the different aspects in these methods. In the AAU case, the formative approach is used during the project process, but this should not formally influence the final result; however, according to the teachers this is very difficult. Regarding the assessment tools, each of the teachers has developed their own judgment system for project assessment based on the current grading scale and their experience and discussion with other teachers. All teachers have developed more or less complicated monitoring systems for the oral examination and for the purpose of giving good quality feedback to the students.

In both cases it is important to assess the process as part of the final results, and students expect feedback in normal language. The study regulations define the way the projects can be assessed, and the number of students in the project groups has a great influence on which methods the teacher can use when assessing the project and giving feedback to the individual students.

We suggest that a combination of the methods used in both cases should be used. The learning outcome should be measurable by the teachers, achievable by the students, and essential to the aims of the learning module. The assessment methods have to be able to evaluate all aspects of the students' learning outcomes. As stated by Rothstein , "it is better to imperfectly measure relevant dimensions than to perfectly measure irrelevant ones" [11].

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185 ISSUES SURROUNDING TEACHING CALCULUS TO ENGINEERING FRESHERS

Larissa Fradkin[1]

1 Sound Mathematics Ltd., Cambridge, UK, l.fradkin@soundmathematics.com

ABSTRACT

Modern undergraduates join science and engineering courses with poorer mathematical background than in the past. University tutors spend more and more time delivering remedial teaching classes. When doing so, most rely on traditional methods of delivery. However, such methods presuppose that the learners have a good memory and a considerable time to practice. These suppositions are particularly unrealistic when dealing with large groups of undergraduates who are so-called ordinary learners, that is, have limited mathematics background and limited study skills. These disadvantages can be overcome when dealing with adult learners. We elaborate on aspects of a specific approach to teaching pre-calculus to engineering students, showing how to put to practice a combination of traditional and modern educational theories, using Socratic dialogue directed at developing freshers' explanatory skills. We report common student misconceptions and suggest how they can be overcome.

Keywords: pre-calculus, engineering freshers, verbalization.

1 INTRODUCTION

It is well recognized that in these days of widening participation undergraduates join science and engineering courses with poorer mathematical background than in the past. It is also widely recognised that in view of that, there is a need for transforming undergraduate STEM education [1]. A large effort is being put by many University tutors into developing additional support and stepping stone classes in maths and promoting project based learning [2]. However, most mathematics teachers covering the basics rely on traditional methods, following school curricula. Such methods presuppose that the learners have a good memory and/or considerable time to practice. These suppositions are particularly unrealistic when dealing with large groups of undergraduates who are so-called ordinary learners, that is, have limited mathematics background, limited memory, limited proficiency in explanatory reasoning, limited interest in the subject and on top of that, limited time and limited study skills, all aggravated by a limited contact with teachers. When additional classes are offered to such learners as optional the attendance is usually meagre. There is no evidence either that the project based learning or presenting mathematical concepts "in context" can be beneficial when the task is to teach mathematical basics to a large class of ordinary learners, particularly, when the basics are to be covered in a short time.

The paper describes a specific approach to teaching most that an engineering student needs to know about functions – in a very efficient manner. We also report common student misconceptions and suggest how they can be overcome.

2 SOCRATIC DIALOGUE BASED ON EULERIAN SEQUENCING FOR TEACHING PRE-CALCULUS

It has been argued in a series of previous publications that even large classes can be taught using the Socratic dialogue [3] – [5]. This can be successful if students are asked questions at random which – provided this is done in a friendly and encouraging manner – assures an almost total engagement. Of course to assure success the questions should be chosen very carefully. We have suggested before that when teaching matgematics they should be based on the so-called Eulerian sequencing of mathematical expressions and solution steps [6]. This approach is different to the one adopted in most modern schools. Both recognize that most people have problems with abstractions, but while the latter proceeds by suggesting various mathematical tricks that require rote learning, our scheme follows a more formal route normally used to teaching professional mathematicians - simplifying it to the bone. Contrary to common misconceptions [8], [9] modern studies in educational psychology [10] – [12] have shown that this way we can impart some understanding and thus furnish undergraduates with much more tools than they could possibly acquire by relying on their imperfect memories. In this paper we suggest precisely how these simplifications can be implemented when approaching the task of teaching freshers pre-calculus in five weeks - as a summer course or else, in a few weeks of the first year. We accompany our proposals with discussion of common learner misconceptions and compare our approach to a more traditional one.

2.1 Main Concept: Functions

In pre-calculus functions are usually introduced as a relationship between dependent and independent variables, although it is better to think of them as operations or chains of operations on independent variables. This allows students to think of functions as generalization of algebraic operations and pre-calculus as the generalization for algebra. The task is alleviated if first algebra is revised along the lines described in [13]. Whether there is time for that or not, students should be reminded of the meaning of the word variable. The discussion has to be short. One of the main principles behind the proposed methodology is that the number of abstract concepts and recipes is reduced to a minimum. Failure to discuss the technical terms and hoping that students will somehow “get an intuitive feel” for them is the main reason for their failure to master the subject. While invoking “an ability to soak up language” might be justified when dealing with younger learners (even this is doubtful when dealing with ordinary unmotivated learners [9]), adult students do not normally display this ability when exposed to ordinary languages, let alone the language of mathematics.

Once the students grasp the concept of a variable, functional notations have to be introduced. While convenient, they require more discussion than is usually offered. We suggest saying something along the following lines:

> *The first choice for a function name is f or f( ) and the second choice is g or g( ). The brackets put after the function name stand for the word of and are functional and not algebraic, which means that no multiplication sign is implied!*

Unless this is spelled out students write things like sin (x) / x = sin, leaving their teachers baffled. Once this common misconception is dealt with it is advisable to address another – the fact that the word function is used in schools to denote the dependent variable f (x). In more advanced texts the word function can take one of two meanings:

> *1. f ( ), an operation or a chain of operations on an independent variable;*
> *2. f(x), a dependent variable, that is the variable obtained when an operation or a chain of operations f ( ) is applied to an independent variable x.*

Which meaning is implied should be understood from the context: If the word function

is not followed by the word of it is most likely to be an operation, otherwise it is most likely to refer to a dependent variable.

While traditionally engineering students are taught to think of functions as rules - black boxes with one or more inputs and one output - it is more helpful to emphasize that to specify a function we need to specify a rule f - (chain of) operation(s) and domain D, a set of allowed values of the independent variable. It is also important to emphasize that to each x in D, f( ) assigns one and only one value y in R, where R is range, a set of all possible values of dependent variable. Students usually struggle with these concepts and it is important to put them across and keep reinforcing them by way of Socratic questioning. Since pictures speak louder than words the best way of doing so is by using a diagrammatic (general pictorial) representation of a function, see fig. 1.

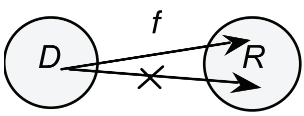


FIGURE 1. *A diagrammatic representation of a function.*

Moreover, it is useful to introduce the concept of a natural domain, e.g. the natural domain of any function of a real variable is all reals, with possible exceptions which arise due to inverse operations that do not lead to a real number, such as division by zero, taking the square root (in fact, any even root) or log.

2.1 Main Concept: Elementary Operations on Functions

The next step is to introduce elementary operations on functions, addition, subtraction, multiplication, composition/decomposition and taking an inverse. While students normally have no difficulty grasping the meaning of the first four operations the operations of composition/ decomposition and taking inverse require extra work. We suggest that before going through exercises the meaning of composition/decomposition, should be first clarified, maybe as follows:

> *Composition is the chain of functions (operations) applied one by one. It amounts to substitution: when performing composition we keep putting in place of arguments their actual expressions. This means that we keep removing brackets inside out. Decomposition (inverse to composition) is sorting out order of operations in a given expression.*

One should not forget that even the word substitution might cause difficulty and some students have to be reminded that it means putting in place of. Similarly, when introducing inverse functions it is important to discuss the notation: students often

confuse the symbol of inverse with the symbol of multiplicative inverse and a diagram in fig. 2 can be used to help them understand that the inverse does not necessarily exist:

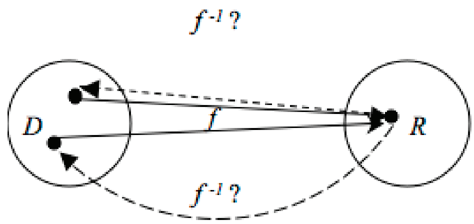


FIGURE 2. *A diagrammatic representation of an inverse function.*

To help students learn how to find inverse functions analytically we suggest that the necessary steps are spelled out supported by an explanatory diagram as in fig. 3.

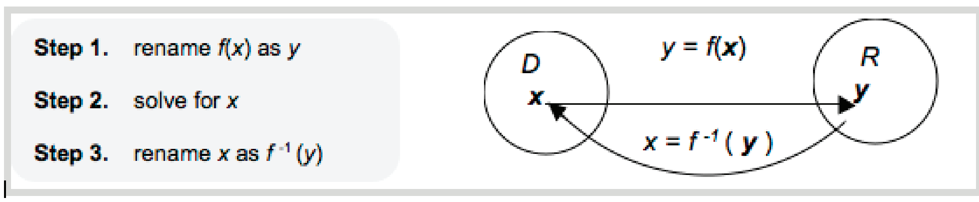


FIGURE 3. *An algorithm for finding an inverse function.*

It is useful to finish this lecture on functions with an extended Order of Operations convention:

B - Operations in Brackets first and then in order of decreasing complexity,
F - Functions f ( )
P- Powers (including inverse operations of roots and logs)
M - Multiplication (including inverse operation of division)
A - Addition (including inverse operation of subtraction)

This can be shortened as in fig. 4.

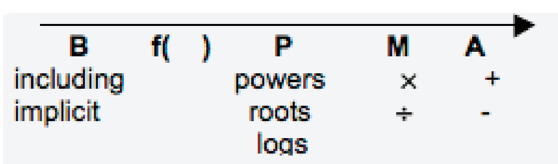


FIGURE 4. *An extended Order of Operations.*

A continual reinforcing of this convention via Socratic questioning strengthens the connection between functions and algebraic operation. The convention is a good organizing principle that alleviates the task of explaining how to perform operations in more advanced mathematical expressions. It also paves way to future explanation of such advanced operations on functions as differentiation and integration.

2.3 Elementary Functions and their Graphs

In the second lecture on functions graph sketching is usually introduced. It is advisable to explain to students that while the diagrammatic representation applies to all functions, each particular real function of a real variable can be visualized using a more specific, graphical, representation. On making sure that students learn to use tables to sketch monomials y = x and y = x2 it is reasonable to introduce polynomials, the Main Theorem of Algebra, the concept of roots, factorization of polynomials and a formula for roots of the quadratic equation. As an optional material one can discuss the principles behind sketching general polynomials. It is extremely important to conduct a Socratic dialogue on the concept of a constant (a number or else a variable which is independent of the independent variable). The second part of this definition is not given in schools and many students fail to recognize constants.

The third lecture on functions can be used to discuss exponential and logarithmic functions, the fact that they are inverse to one another as well as their domains, ranges and graphs. At this stage we can introduce Napier's constant, emphasizing that it is an irrational number and explain that its importance becomes clear only later. While the graph of natural log can be sketched using the same table as the exponential it is helpful to introduce and use here the general algorithm for sketching inverse functions.

Before introducing trigonometric functions it is important to revise the necessary trigonometry, namely angles, the irrational number π and right angle triangles. It is important to make a distinction between dimensional units of angles (degrees, minutes etc.) and the non-dimensional unit of radian. Several exercises are required for students to memorize how to describe standard angles using degrees or radians before introducing Pythagoras Theorem and trigonometric ratios.

In the fourth lecture on functions one can use the Unit Rod Diagram to generalize the trigonometric ratios to trigonometric functions and discuss at length the table required to sketch y = sin x and y = cos x. In the same week one can introduce the inverse trigonometric functions and their graphs and even hyperbolic functions and their graphs. This can be done by an efficient use of tutorial time or an extra lecture.

2.4 Sketching Linear Compositions of Functions

The fifth lecture can be devoted to sketching by simple transformations. While this is a useful engineering skill the principles behind the sketching technique remain obscure to most students, particularly, when transformations are made along the x-axis. Yet there is a very straightforward explanation based on the organising principles of inverse function and order of operations and reinforcing students' ability to transpose equations.

Let us assume that we know how to sketch a function y=f(x) and consider compositions which involve it and addition of a constant to an independent variable x or dependent variable y, or else multiplication by a constant of an independent variable x or dependent variable y. Such compositions may be sketched using simple transformations (translation, scaling or reflection) of the curve y = f (x). In fig. 5 we suggest how to discuss sketching by translation. Scaling and reflection can be treated in a similar manner. One can then introduce an algorithm for sketching composite functions which involve several simple transformations.

The next steps are to introduce the method of completing the square and show students how to sketch parabolas by simple transformations. This is much more instructive than

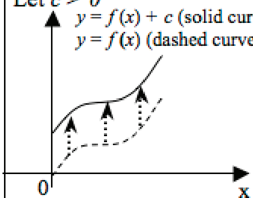
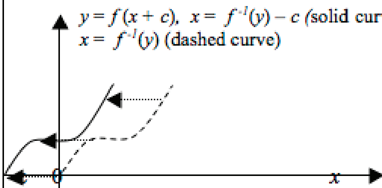
Sketch y = f (x) + c (+c – last operation)	Sketch y = f (x + c) (+c – first operation)
Let $c > 0$  	Let $c > 0$ 
Algebraic description: addition of a constant c to y **For every x,** transformed $y = f(x) + c \Rightarrow$ **transformed** y = **old** $y + c$ **Geometrical description:** translation wrt y-axis by c $c > 0$ - shifting up $c < 0$ - shifting down	**Algebraic description:** addition of a constant c to x **For every y,** transformed $x = f^{-1}(y) - c \Rightarrow$ **transformed** x = **old** $x - c$ **Geometrical description:** translation wrt x-axis by $-c$ $c > 0$ - shifting left $c < 0$ - shifting right

FIGURE 4. *Explaining translation (the abbreviation wrt stands for with respect to).*

encouraging them to play with software packages that allow them to see that changing various coefficients of a quadratic expression changes the corresponding the graph - without elucidating why and how. The fifth lecture can be spent on practicing the newly acquired skills and one last method of sketching graphs – by pointwise operations. Students do not have much difficulty doing that but need to practice the method a few times under supervision.

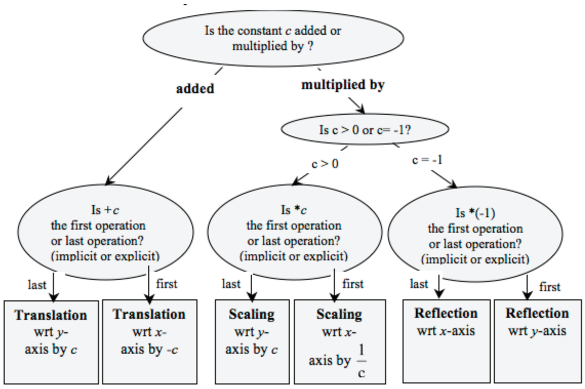


FIGURE 5. *Explaining translation (the abbreviation wrt stands for with respect to),*

It is advisable to start every lecture on pre-calculus with a Socratic dialogue on what do we study in algebra (variables and operations on variables) and pre-calculus (functions and operations on functions), going over a concept map like the one in fig. 6.

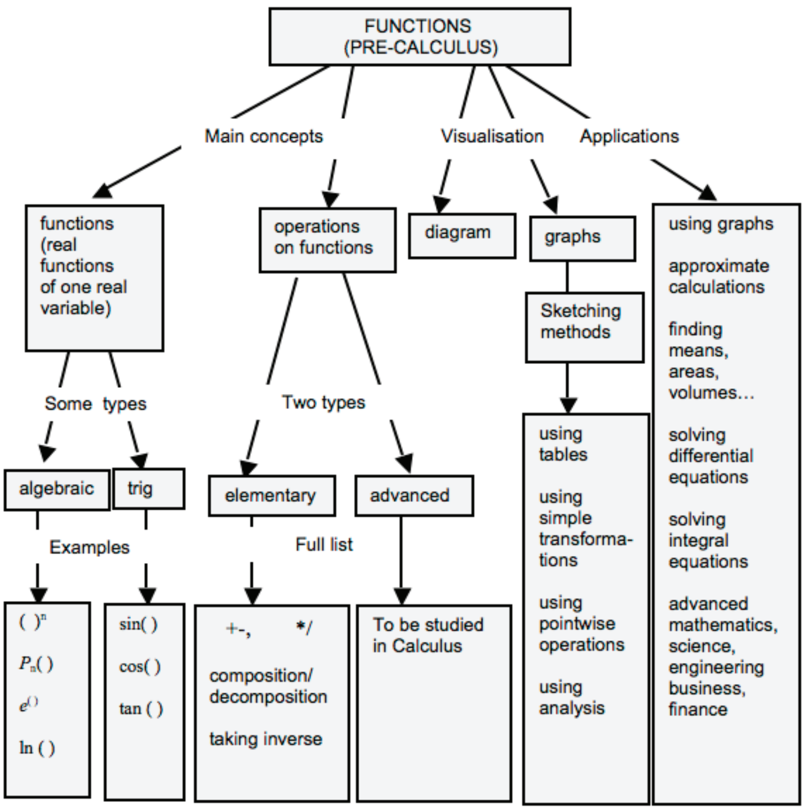


FIGURE 6. *A concept map for pre-calculus.*

3 CONCLUSIONS

The methodology described in this paper has been tried and tested on cohorts of engineering students studying electrical, electronics and communications engineering for 16 years at a UK University of widening participation and brought the exam pass rate form the original 40% to 70%. For the past five out of these 16 years the classes included civil, mechanical and chemical engineering students as well. The results are particularly significant, because the exam papers contained non-routine questions and questions the students have never seen before. The success could not be achieved without many administrative measures aimed at increasing student attendance and various psychological devices aimed at facilitating student transition from passive recipients of facts and tricks who try to memorize enough to pass to genuine active learners. The studies of overall department statistics revealed no correlation between the quality of student qualifications on entry and the quality of their BEng degrees.

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190 IMPROVING FIRST YEAR RETENTION IN COMPUTER SCIENCE BY INTRODUCING PROGRAMMING IN SCHOOLS

Sonya Coleman[1], Anne Hinds[2], Eric Nichols[3] & Heather Sayers[4]

Faculty of Computing and Engineering, University of Ulster, Northern Ireland, UK,
1 sa.coleman@ulster.ac.uk, 2 a.hinds@ulster.ac.uk, 3 Nichols-E1@email.ulster.ac.uk,
4 hm.sayers@ulster.ac.uk

ABSTRACT

An 'Introduction to Programming' course has been delivered in a number of local secondary level schools for two years. The course addresses fundamental programming concepts such as variable declarations, conditional statements, loops etc. in a fun and engaging way providing Year 13 and 14 pupils with sufficient knowledge to help them to make informed decisions on undertaking further study and a career in computing and engineering disciplines, thereby improving retention within the subject. In this paper, we outline a follow-on study conducted with students who participated in the project and subsequently started first year of a Computer Science related degree. We present results on the student performance in programming modules in comparison to those who had not been exposed to programming prior to university entry.

Keywords: Programming, retention

1 INTRODUCTION

Non-completion is a significant problem within Northern Ireland, with non-completion rates reaching as high as 14.4% (2004/05) which was significantly higher than the UK benchmark of 9.7% in that year. Within the Faculty of Computing and Engineering, and more specifically the School of Computing and Intelligent Systems (SCIS), there is quite a high rate of non-completion, mainly due to a high rate of early leavers (who often indicate that the course was not what they had expected) and those who fail first year.

We have worked hard to decrease the number of students failing first year over a three year period, and in the 2008/09 academic year managed to reduce retention to below the Faculty average. Initiatives such as small group tutorials and extended studies advice and inductions have helped to improve retention figures. However, the non-completion rates for the Faculty leave much room for further improvement. Therefore, by introducing programming to secondary schools, we aim to give the students a feel for the types of things they would be doing when studying STEM subjects in HE. In addition, as there are two programming modules in the first year of single honours programmes, learning the fundamentals prior to admission should be highly beneficial in improving student performance and ultimately decreasing non-completion rates. In addition, Foster [4] has pointed out that in order to exist in any global economy and as a global competitor we need a highly skilled workforce capable of attracting international investment. He postulates that this responsibility of producing the skilled workforce lies with third level education facilitators. One way to achieve this, as evidenced by recommendations of the National Council for Educational Excellence [5, 6], is to strengthen links between schools and tertiary level institutions. This project "Widening Access by Introducing Programming in Schools" (WABIPS) provides a partnership between tertiary and secondary level education enriching the school curriculum and facilitating a communication medium for the schools by increasing accessibility to education and life at third level. This project is about an articulation between effecting change for the 14-19 year old student [1, 2, 3] through learning, engagement and sustainability in computing and engineering technologies.

The overall goal of taking programming out to these schools is to provide pupils with introductory programming skills, and to inspire both female and male pupils from all backgrounds to undertake further study in STEM disciplines. Many schools run an enrichment programme for the Year 13 and 14 pupils during which they have the option to do extra curricular studies such as studying for the DVLNI Theory test. It is via this forum that we provided one hour per week of programming in each selected school. The pupils had a combination of theory and practice on completion of the course. In the first year of the project we aimed to specifically address the issue of non-completion by targeting schools that currently have pupils who progress to courses within the School of Computing and Intelligent Systems (SCIS) at the University of Ulster.

We targeted local secondary schools with the intention of encouraging pupils to progress to computing and engineering related courses. We have conducted a follow-on study with students who participated in the WABIPS project at school and then started first year of a Computer Science related degree. We present results on the student performance in programming modules in comparison to those who had not been exposed to programming prior to university entry.

2 PROJECT IMPLEMENTATION

In the first year of the project we delivered the course in schools from which we normally receive degree applications; participation details are given in Table 1 for term 1. School names are given as SJC, OIC and SBC for anonymity. Table 2 presents the school participation for term 2. In addition to the three schools from term 1 there is an additional school name given as LC in term 2. Figure 1 presents a graphical representation of the number of male and female participants within each school. We are encouraging further applications from these schools, and attempting to convert applicants to actual students who will successfully complete their degrees. WABIPS provides the secondary school pupils with fundamental programming skills and an insight into what they will study in future years at UU within computing and engineering. By providing potential applicants with a foundation to the programming aspects of the degree programme at secondary school level, confidence and self-efficacy with these programming concepts should result in greater participation and a heightened sense of achievement for each student should they sit on a degree module hereafter.

TABLE 1. *Pupil participation Term1.*

School	Total No. Pupils	Male	Female
SJC	11	11	0
OIC	11	8	3
SBC Yr. 14	7	4	3

TABLE 2. *Pupil participation Term 2.*

School	Total No. Pupils	Male	Female
SJC	11	11	0
OIC	11	8	3
SBC Yr. 13	15	10	5
LC	4	2	2

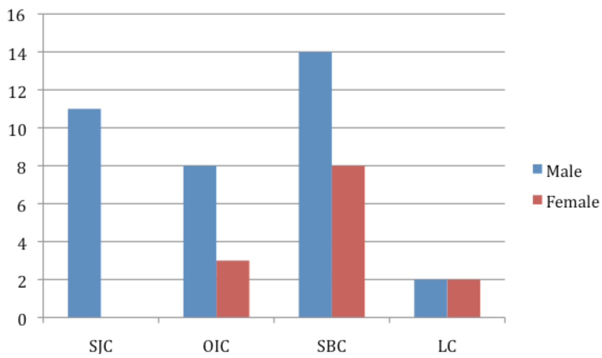

FIGURE 1. *Representation of male and female students participants.*

The learning theories that were implemented to deliver the introductory programming to the secondary school pupils was reflective of building on prior knowledge from STEM subjects already covered up to GCSE level. The theory and the practical aspects of the computer programming module were taught in a way that reflected programming connections with the real world through relevant examples. In essence, this promoted confidence through repetition of prior knowledge, which was extended into new and layered knowledge for programming. The introduction of programming was therefore not seen as an isolated, scary and completely new practice, but instead one that embraced many facets of education and learning and then applied them in a new subject relating to technology.

WABIPS has both female and male instructors to facilitate in the delivery of the classes thereby neutralising the impression of the computing domain as a predominantly male one. Role modelling can break the stereotypical view that students often hold of computer scientists being male, which is more reflective of what the news media and the film world propagates.

In addition, a three day course was delivered to another school in June 2011, specifically targeting pupils who planned to study a computer science related discipline at tertiary level; approximately 40 pupils attended this.

3 PROGRESSION TO TERTIARY LEVEL

Although this 'Introduction to Programming' course was delivered to approximately 100 pupils throughout the academic year 10/11, only approximately 50 of these students were year 14, i.e. progressing to tertiary level education in September 2011. Of these, there was no expectation that all students would progress to study in the University of Ulster, and our aim was to prepare pupils for computer science related disciplines at any university to help to solve a UK wide problem. At this stage we have identified six students in first year within SCIS who have participated in the WABIPS programme; it should be noted that the WABIPS course is delivered only in secondary schools and not grammar schools.

We have analysed the results for all Semester 1 modules taken by the six students to determine how they perform in comparison to the other students in their cohorts. In Table 3 we present the percentage averages for the Programming 1 module; the module average was 68% and the average for the students who participated in WABIPS is 75.2%, - 7.2% higher than the average student.

TABLE 3. Programming I results.

	Programming
Average:	68
WABIPS:	75.2
Difference:	7.2

We conducted a further cross-correlation using the marks from the other Semester 1 modules that the students undertake. The results of this are presented in Table 4. We can see from Table 4 that the students which took part in the WABIPS course obtained higher than the average mark in all modules except Business Information Systems. A graphical presentation of these results is presented in Figure 2.

The results could suggest that the students that were keen enough to undertake the 'Introduction to Programming' course were in general good students or it could suggest that by having a good basis of fundamental programming, they were able to spend equal time on all modules and contribute strongly to coursework etc. in all areas. It is often found that students dedicate a lot of time to Programming 1 as they tend to find it the most difficult Semester 1 module.

TABLE 4. Module results.

	Introduction to games	Systems Analysis and Design:	Maths 1	Business Information Systems
Average:	59	59	69	52
WABIPS:	67	65	74.33	47.66
Difference:	8	6	5.33	-4.34

Table 4 Module results

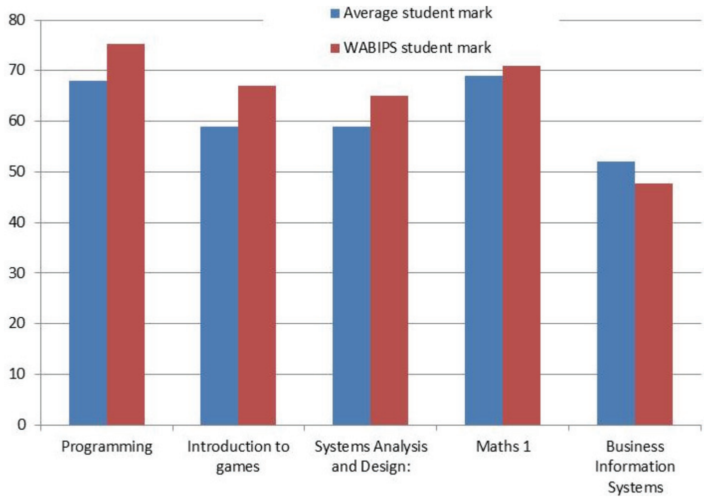

FIGURE 2. *Average marks per module for students compared with students that participated in the WABIPS programme.*

4 EVALUATION

On completion of the course in schools in the academic year 2010/11, feedback was obtained from the pupils via a questionnaire that was designed to gather information regarding the current subjects that the pupils are studying for their A Level exams and their views in terms of applying to further education. The questionnaire was also designed with the view to capturing more general information that could be used to further tailor the course to suit the audience. Two questionnaires were designed: one for capturing the information of the Year 13 group and one to evaluate the decisions of the Year 14 group especially in relation to degree subjects and university application preferences, which the Year 13's have still time to decide upon. Overall feedback was excellent and details can be found in [7].

More specifically, informal feedback was obtained from the six students now studying a computing related degree in SCIS at the University of Ulster. Their feedback indicated that they felt the 'Introduction to Programming' course was very useful to helping them through the first semester of year 1. Comments included:

> *"The course helped me a lot of the Programming module"*

> *"Having a introduction to programming was very helpful coming into this degree and made things seem a lot easier"*

5 CONCLUSION

We have presented a follow-on study involving six students who took part in the WABIPS project. The results indicate that these students are currently performing well above average and we will continue to monitor this performance. We will extend this analysis over the coming years when we have a larger number of students entering first year from the WABIPS project and from the additional three day course, one of which ran in October 2012 with an additional three scheduled in June 2012. Additionally, we will endeavour to make contact (via the schools) with students who undertook the 'Introduction to Programming' course that are now studying computing related degrees at other universities.

6 ACKNOWLEDGEMENTS

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192 TEACHING INNOVATION PROJECTS IN UNIVERSITIES AT TAMPERE

Toni Pippola[1], Timo Poranen[2], Matti Vuori[3], Ville Kairamo[4] & Jarmo Tuominiemi[4]

1 Tampere University of Applied Sciences, Tampere, Finland, toni.pippola@tamk.fi
2 University of Tampere, Tampere, Finland, timo.t.poranen@uta.fi
3 Tampere University of Technology, Tampere, Finland, matti.p.vuori@tut.fi
4 Hermia Ltd., Tampere, Finland, {ville.kairamo, jarmo.tuominiemi}@hermia.fi

ABSTRACT

Global change in societies and work life has raised a need to ensure that students have competence to work in a multicultural and multidisciplinary work community and project teams. To meet this challenge, three universities at Tampere in collaboration with Demola designed a new course concept, Innovation Project to integrate Demola activities to curricula. Project teams are formed from students of different universities having greatly varying backgrounds. The goal of the team is to produce in collaboration with a company partner a demo of an innovative concept. University teachers and Demola facilitators help the team to reach the project goal. In this article, we describe the Innovation Project course concept and compare it against traditional project courses.

Keywords: Innovation, multidisciplinary, multicultural, university, project.

1 INTRODUCTION

Project work courses are common at computer science departments all around the world [1]. A standard goal of a traditional course is to familiarize students into the design, implementation and testing of (software) systems and into working in a managed project. An outcome from a project is a (software) product. Usually, all team members are studying the same subject and they come from the same department. Project topics are given by the client and there is no much space for innovations.

A generally accepted definition for innovation is given by OECD [2]: “Innovation is the creation of better or more effective products, processes, services, technologies, or ideas that are accepted by markets, governments, and society. Innovation differs from invention in that innovation refers to the use of a new idea or method, whereas invention refers more directly to the creation of the idea or method itself.”

Global changes in societies and work environments have raised a need to ensure that students have capabilities to work in a multicultural and multidisciplinary work community and project teams. The students should be able to understand, learn, and apply fast changing technologies. New crucial competencies include understanding the software product concepts and communicating of the essential features to all stakeholders, thus raising the abstraction level of low level design to product and business issues.

To meet these challenges, three universities in collaboration with Demola [3], an open innovation platform located in Tampere, designed a new course concept, Innovation Project to integrate Demola activities into curricula. In the course, project teams are formed of students of different universities. Students' backgrounds vary (arts, computer science, interactive technology, management, pedagogy, etc.). Based on the Demola model all projects have a real project partner, and topics are related to new technologies or services. It is also required that all projects have a freedom to innovate, the project goal and design process is not completely fixed.

In this work, we describe Innovation Project course organisation and give preliminary assessment of its benefits and points to be developed. We also compare traditional project work course and Innovation Project. In Section 2 we give an overview to changes in work life and to Demola's history. In Section 3, we describe the Innovation Project course concept. In Section 4, we list students', teachers', and partners' experiences. Finally, in Section 5, we discuss on future research directions and improvements to the course organisation.

2 BACKGROUND

In a recent report [4], competences what the business and industry will need and how that competence can be developed were assessed. It was claimed that the nature of society is changing and that we are moving from information society towards experience and experimental society. The business logic of companies will be more and more based on innovations. The central competencies in the new environment are by the report: (a) willingness and ability to work in a new way, (b) ability to network, (c) internationalism, (d) business skills, (e) technological skills, (f) environmental skills, (g) service skills, and (h) design skills. The report notes that even in the future "super individuals" are not needed – it is essential that the necessary competencies are found in teams and networks. The report also emphasises changes in traditional learning towards learning together, in networks.

Another relevant Finnish report [5] concludes that while having the professional engineer's core skills is naturally a critical factor, much more is needed. Some items that the report sees important in the future include: Creativity and innovativeness, business skills, usability of technology and productization, risk management and an engineer's ability to see things three steps ahead, a sense of responsibility and ethics, shared expertise, collective learning and facilitating skills, problem-based thinking, reflection of own activity, collaboration, ability to communicate own expertise to others, understanding of differences in people as potential, ability to stand stress and uncertainty, and ability to learn by doing.

Need to enhance creativity and innovativeness in education have provoked new courses in schools and universities. One widely known design engineering course is Stanford University's ME310 [6]. During this one year course student teams prototype and test design concepts and in the end they create a proof-of-concept that demonstrates their ideas. Students also participate in design workshops, give presentations and write in-depth project documentation. The teams collaborate with their corporate partners and also with teams from other universities. Fixson [7] has compared and analyzed innovation education in universities in US. Most of the courses contain lectures and workshops, and students' assessment is based on the final prototype, presentations and reports. See also a paper by Elam et al. [8] on educational institution strategies for increasing innovation in United States and a study on using structured teaching methods in innovation and product development by Fernandes et al. [9].

Most approaches to academia-industry co-operation have their limitations in supporting innovative learning. Also in Tampere, the focus has traditionally been towards educating industrial practises and tools for students and not in the creation of new ideas. Based on the input from the industry Hermia Ltd. started to develop Demola [3] model in 2008 to create an environment for university-business co-creation and innovation education for talented students. Development was a co-operative effort of Hermia Ltd, companies like Nokia Research Center, universities and city of Tampere. Later Demola activities have also triggered e.g. the development of Protomo [10] pre-incubator network operating in eight cities around Finland.

In Demola, university students develop product and service demo concepts together with companies and create new solutions to real-life problems. Demola provides an inspiring atmosphere of creative co-creation and new learning opportunities for students and professionals of different universities and organisations. The immaterial rights of the results stay with the multidisciplinary student teams. Companies can then purchase the rights or license the products or services from them. Demola also creates new spinoff companies around the innovations. Since August 2008 over 200 Demola projects have been conducted. Over 1100 students have participated in Demola co-creation and 35% of the students have been international. As a result in 93 % of the projects, the results have been claimed for business use according to the Demola IPR framework and approximately 15 % of the students have been recruited by the project partners. Project partners have also filled some patent applications and bought all rights to the results. Furthermore a few start-ups have been founded by Demola alumni and many of the students have joined a team developing a start-up in Protomo incubator.

Three universities in Tampere region, Tampere University of Applied Sciences (TAMK), Tampere University of Technology (TUT) and University of Tampere (UTA), started in 2010 discussions with Demola to organize a common course, Innovation Project. The first course was organized in fall 2011.

3 INNOVATION PROJECT

The main learning goals of the Innovation Project are described as follows. After completing the course a student is expected to be able to a) participate in a multicultural and multidisciplinary team that creates a demo or a prototype of a product, service or other innovation, b) understand basics of good project working practices, project scheduling and reporting c) apply agile project practices, design and product research methods in project working and d) present project outcomes orally and in writing.

The course runs with different names in universities and different courses are connected by Demola. The basic idea is the same: students enroll to a course on their home university and then participation in the Innovation Project gives credits. Students might study arts and media, computer science, interactive technology, management, translation studies, pedagogy, electronic engineering etc.

The course is given twice in an academic year, first round starts in September and ends in December, the second round starts in January and ends in May. Universities usually have their own introductory lecture given by the corresponding teacher and a Demola's representative telling about the Demola. Registration methods vary in universities, but all students must apply for projects using Demola's website. The student can browse all available projects and apply for them. In the project descriptions the problem area and the needed skills are described. After the application deadline is over, Demola staff form project groups. This is actually quite a complicated task because of many applications and conflicting wishes given by partner organizations and students. Not all students get in the project they applied and for these students Demola staff tries to find another suitable project. Sometimes the Demola staff is not able to find a project for a student, and in these cases the student must apply for the course and projects again later.

During the project the project team is collaborating with their project partners and teachers. Demola staff facilitates the projects and gives support to all stakeholders. Usually project partner meets the team weekly to support the team to find a solution. A teacher's main task is to evaluate the project and give credits. The teacher is project's connection to the academic world and research, and in some cases the teacher can give to the team knowledge on current research on the project's field. The teacher can also raise up process related problems, like insufficient management or passive participation. Each project team has 2-4 teachers depending on number of different courses students are participating. Usually teachers participate only in the main project milestone meetings and follow project presentations. Some teachers organized their work so that they were able to spend whole workdays at Demola premises meeting, collaborating, and discussing with their students.

Also the Demola community plays an important role. Basically, anyone who is present at Demola can be asked to give comments and help with tasks that need collaboration with external people. Get-together events, workshops, free coffee, and some free-time events help to create Demola to be a cozy workplace. There are no opaque walls at Demola, the area is open for seeing what other teams are doing.

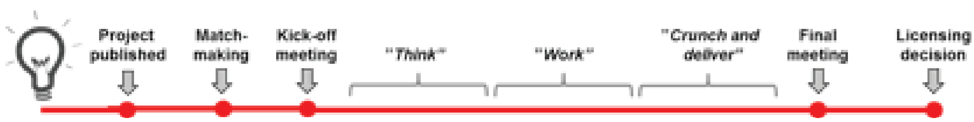

FIGURE 1. *Project lifecycle.*

The work process is illustrated in Figure 1. After the teams are formed, the facilitator invites the group to a kick-off meeting. Then the team starts to work with the project topic in collaboration with the partner and writes a project plan. The project plan is reviewed with all stakeholders and main project milestones are agreed. Then there are usually 2-3 other review meetings during the project. In these review meetings the team shows what they have done so far to get feedback. The project closes in a final meeting where a final report written by the team is discussed. All the time the team actively collaborates with the partner. Most teams have several fixed weekly meeting / workdays at Demola.

In addition to the normal work, Demola organizes workshops and other training sessions for teams. Workshop topics vary from course to course, and fall 2011 agile development, gamely concept design, service design, user experience, performing skills, commersialisation, and productification and sales message workshops were organized. To learn presentation and marketing skills, the teams give two elevator pitches [11] during the project.

During fall 2011 there were 35 teams working on Demola projects. There were three to eight students in one project group. One student was working approximately 100-200 hours with the project creating total of 500-700 working hours per project. As a result, a student earned approximately 5-10 ECTS credits per project.

Usually the project topics are related to new technology, applications and services. The clients came from many different areas: industrial, governmental, software companies, universities etc. The expected level of projects is usually a proper demo, but expectations of the outcome can also vary from concept designs to even “to be released” kind of products. Fall 2011 projects can be sorted in seven categories: services, applications, games, presentations, information systems, technical infrastructure and marketing. Most of the projects were related to services (12/35). The second biggest category was applications (9/35) followed by games (7/35). There were also some projects related to information systems (3/35) and presentations (3/35). Only one (1/35) was related to technical infrastructure. The expected level of the projects was sorted in four categories: prototype, demo, concept design, and release. The most expected level category was prototype 17/35). The second biggest category was demo (8/35). Concept designs (5/35) and releases (5/35) were both expected as an output in few projects.

The main differences of traditional project work courses and innovation project course are collected into Table 1. In the first column there is an attribute (risk level, scope, mental focus, the main quality factors, relation to tradition, rules and thinking patterns, main reusable results, lifecycle emphasis, working environment, communication, language, product rights, skill set and learning experience), and then the attribute is described in the context of traditional project and innovation project.

TABLE 1. Comparison of traditional project work course and innovation project.

Attribute	Traditional project work course	Innovation Project course
Uncertainty, risk level	Moderate risk	High risk, high uncertainty
Scope	Defined	Defined
Mental focus	Processes, routines, execution	Substance, business
Main quality factors	Fulfilling customer needs, total quality of action, re-usability of results	Value and re-usability of concept, new possibilities – creative thinking, product potential
Relation to tradition, rules, thinking patterns	Follow rules, use heuristics	Break rules, think differently
Main reusable result	Product, documents	Idea, conclusion, principles
Lifecycle emphasis	All equally	Concept, fuzzy front end feasibility study, proof of concept, marketing
Working environment	Closed, homogeneous, one culture, team work alone	Open space, networking, heterogeneous, multicultural, international, all teams in one space
Communication	Inside team, rhythmic with teacher / long cycle	Inside team, between teams, short cycle with customer/partner, networking
Language	Native language	English
Product rights	Customer	Team
Skill set	Systematic project work, professional action, development & research methods, teamwork	Problem solving, teamwork, creativity, handling uncertainty
Learning experience	Project work, project management, how methods and theory work in practice, teamwork	Project work, team work, potential of creativity, intercultural working

A project scope is defined in both project types, but the risk and uncertainty level is clearly higher in innovation projects. Mental focus in traditional projects is in processes, routines and project execution, in innovation projects the focus is in substance and business. The main quality factor in innovation projects is innovating new possibilities and product's potential verified by a demo, not just fulfilling the customer's needs. Project outcomes are different. The main deliverables of a traditional project are documents and product, in innovation projects team tries to generate usable ideas and verify applicability of their innovations. In innovation projects, the product rights belong to the team, whereas in the traditional projects product rights are usually owned by the customer.

Team formation and working environments differ. In innovation projects, the teams are heterogeneous and multicultural; traditional project teams have members only from one culture with similar backgrounds. Multicultural teams make it necessary to use English as a working language. The best working environment for innovation projects is an open space with a possibility to closely collaborate with other people.

Working in an innovation project requires especially skills to handle uncertainty and the ability to be creative; not just to follow managers' orders. In both project types, students get an experience on participating in a project, but in innovation projects emphasis is on intercultural working.

4 EXPERIENCES

During the course feedback was collected from students (mid-project and after its end), companies and teachers.

For the students we refer here the mid-project survey as the analysis of the end survey is not yet available. The students saw their Demola project and the course as an empowering new way to work, learn and challenge their self in the course of their studies. Students had especially seen the new way of working compared to traditional working methods as important learning experience. Students had never before had this kind of opportunity to work in such multicultural and especially multidisciplinary teams with real life problems. The main learning experiences that the students point out from Demola projects were: realizing their own value as a member of a team (empowerment), multicultural cooperation and team working skills, practical skills and working experience and entrepreneur mindset.

Feedback collected from the project partners gave us a bit of insight that the learning process in the Demola projects is not one sided. Few key things that partners point out were that the project forces the partner to take some distance from their own technologies and see them more objectively and critically, students can be really creative when the project is facing problems, team members had professional skills in spite of the fact that they were students. Based on the feedback all of the project partners would recommend Demola projects to other companies.

There were roughly 15 teachers involved in project supervision. About half of the teachers were participating for the first time in Demola activities. The main positive experiences that teacher reported were possibility to "work differently outside university" and having co-operation with other teachers and companies. Students working in heterogeneous and multicultural teams were also seen as a motivating force to creativity. Teachers reported some problems in course organization and teaching. Some teachers felt that their role in the project is not clear and that "having too many teachers for a project is a waste of resources". Because Demola was located in the center of Tampere, commuting to Demola and back took time from teachers.

5 CONCLUSION

Although the first course implementation had organizational problems, all parties saw numerous benefits from collaboration. The course will be continually improved together with teachers and Demola staff. The learning goals mentioned in Section 3 can be seen to be reached by all students who completed the course based on students' and companies' feedback and teachers' views. In future, the Innovation Project course provides an excellent platform to analyze and improve methods of teaching and to facilitate innovativeness in student teams.

6 ACKNOWLEDGEMENTS

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193 PEDAGOGIC ANALYSIS FROM AALTO UNIVERSITY SCHOOL OF CHEMICAL TECHNOLOGY AT HIGHLIGHTS OF MOT – INTEGRATIVE EDUCATIONAL METHODOLOGY

Clara Amelia de Oliveira[1]

1 Santa Catarina Federal University, Florianopolis, Brazil, clara@inf.ufsc.br

ABSTRACT

The present paper discusses about integrative view in education following the "Integration in Curriculum Development" Workshop, at ICEE 2011, Belfast. This workshop has been presented by the School of Chemical Technology from Aalto University, Finland. The mentioned workshop presents an opportunity to experts to discuss together about integration in education. This workshop inspired the author to expose the Thematic Oriented Methodology- MOT point of view, now concerning the curriculum development focus. The curriculum development instance opens doors to convert integrative view into real world implementations. The University of Aalto proposal is innovative and its directives will be enhanced by the author analysis specially comparing with the theoretical directives from Object Oriented modelling tool, born at Oslo University under Informatics programming tool. The Object Oriented modelling tool can be implemented several ways. One of those possibilities, proposed by the present paper, refers to Object Oriented tool as a support to develop an integrative educational methodology. This paper contribution concerns to present how to use this modelling tool towards integrative curricular development. Potentiality of resources is direct related with curricular vertical structure obtained under integrative focus.

Keywords: Integrative Methodology, Object Oriented Tool, Curriculum Development.

1 INTRODUCTION

Integration is a core principle which deep affects implementation of educational proposals. Working stark over this principle, the Aalto University, Finland, has developed a new Degree Program of Bioproduct Technology (BPT). The first course began in 2010. The methodology involves extensive cooperation within the School of Chemical Technology, formerly known as Faculty of Chemistry and Material Sciences, and the University reinforcing the importance of integrative view since the administrative instance. Considering "that all sorts and levels of integration is needed to create a Degree Program", this justifies a discussion about this abstract and important principle. The workshop titled "Integration in Curriculum Development", [1] has illustrated core aspects, developed by BPT Degree Program, related with integration principle which can be summarized, as follows: work together to arrive to synthesis proposals; integrating Natural Sciences into professional subjects; integrating English language in teaching program; integrating working life skills providing, for example, mathematics within degree program themes; applying sustainability concept in teaching program.

First it will be presented the concept of integration concerning to disciplinary, multidisciplinary and interdisciplinary knowledge approach. It will be also presented the concept of complexity, which links with the integration idea, as expressed by Edgar Morin, Mobile Chair from UNESCO Complex Thought Cathedra.[2] After this, they are presented the Object-Oriented tool directives, [3]-[6] which support Thematic Oriented Educational Methodology (MOT), [7] associated with the integration principle. It will be enhanced the influence from Object Oriented modelling tool in MOT proposal and how they can contribute to the BPT Degree Program pedagogic discussion, in terms of a real world educational implementation.

2 INTEGRATION CONCEPT UNDER SEVERAL EPISTEMOLOGICAL APPROACHES

Integrative approach concept concerns to a wide range of possible implementations under different levels of generality. Considering nature always embeds some kind of integration in all levels and correlations, integration is considered as a natural concept, present everywhere in nature, since the atom parts physical union until big transversal themes integration. Three epistemological approaches levels to treat knowledge integration can be classified in a vertical hierarchy from generic to specialized level.

a) Interdisciplinary Approach: generic knowledge approach synthesis from transversal theme, called object of study. It embeds integration (synthesis) between, considered a priori, divergent areas. For example, the object of study titled "development of bio products under international requirements". The integrated subjects belong to very different area in terms of knowledge generalization level.

b) Multi disciplinary Approach: still generic knowledge approach synthesis from affinity areas. For example, the object of study titled "development of material science products", under technical approach, embedding biomaterial and forest products. The integrated subjects belong to affinity areas in terms of knowledge generalization level.

c) Disciplinary Approach: specialized knowledge approach synthesis from specific area. It embeds knowledge integration between several basic areas. For example, the object of study titled "development of raw material products". The integrated subjects belong inner parts like biology, chemistry, physics and mathematical.

Interdisciplinary knowledge approach is equivalent to complex approach. Edgar Morin, Mobile Chair from UNESCO Complex Thought Cathedra defines complexity as: "Complexus means that which is woven together. In fact there is complexity whenever the various elements (economic, political, sociological, psychological, emotional, mythological) that compose a whole are inseparable and there is inter-retroactive, interactive, interdependent tissue between the subject of knowledge and its context, the parts and the whole, the whole and the parts, the parts amongst themselves ".[2] Naturally integration concept is deep related with complexity concept.

Table 1 suggests some hypothetic objects of study extracted from BPT Degree Program curricular subjects. Those chosen examples are classified under different knowledge approach according to their scope generality level.

TABLE 1. Different Epistemological Approaches.

Epistemological Approach	Knowledge Hierarchy
Interdisciplinary focus: transversal theme subject Object of Study: BIOPRODUCTS UNDER INTERNATIONAL REQUIREMENTS (high level of generality integration)	Knowledge Categories: sustainability + human health/rights+economics natural sciences + bio materials; chemistry + biology+ physics +mathematics+ ...;
Multidisciplinary focus: technical theme subject Object of Study: MATERIAL SCIENCE (middle level of generality integration)	Knowledge Categories: biomaterial + forest products; raw material, synthetic material chemistry+biology+physics+mathematics+ ...
Disciplinary focus: specific technical subject Object of Study: RAW MATERIAL (particular integration)	Knowledge Categories: chemistry+ biology+ physics+mathematics+...;

Epistemological approach direct affects educational projects concerning the way, not only, knowledge nor educational environment is treated. Integration concept is useful in education because it deals with perspectives affecting from curriculum organization until the whole educational project.

The illustrated examples show different level of integration in terms of a vertical hierarchy from generic until specific knowledge categories. The three level examples reinforce integrative focus is always present as a natural parameter. Each epistemological approach is useful to think about different educational models. Each example can be converted in an interdisciplinary focus if it is, somehow, implemented, since the first glance, knowledge aspects like the insertion of those themes in cultural society.

The next question refers to the development of an educational methodology which facilitates implementation of an interdisciplinary knowledge focus under integrative pedagogic view.

3 THEMATIC-ORIENTED METHODOLOGY (MOT) SUPPORTED BY OBJECT-ORIENTED MODELLING TOOL (O.-O.)

Object-Oriented modelling tool is a knowledge representational tool useful to develop knowledge systems in informatics domain. It favours development of knowledge categories exploring modularization both in vertical and horizontal structures. But its speciality is to stimulate development of vertical structures under inheritance principle allowing reuse of knowledge categories. This property facilitates development and maintenance of big systems. O.-O. Modelling tool works over three abstract operations. The abstraction (operation zero) refers to the level of generality of abstract model; the generalization x specialization (operation one) refers to vertical hierarchy of knowledge model, and, the aggregation x decomposition (operation three), refers to horizontal hierarchy of knowledge model. See Table 2.

TABLE 2. Object-Oriented Modelling Operations.

Operation ZERO: abstraction
Operation ONE: generalization x specialization
Operation TWO: aggregation x decomposition

Thematic-Oriented Methodology (MOT) is an educational implementation derived from Object-Oriented tool considering knowledge focus as a high generality level theme. MOT proposal embeds at least four modules in terms of educational modelling. See Table 3. The first module refers to knowledge approach under administrative pedagogic instance that permits a curricular design under integrative/complex approach. It refers to the level of generality in terms of knowledge model. The chosen theme abstracts (subtracts) the reality creating a model, as well as possible, near to real world. It concerns to real nature condition where all things are together, without knowledge fragmentation, in accordance with the Morin complexity definition already mentioned. Now it is possible to unify nomenclature of real world, complexity, interdisciplinary, thematic approach where integration aspect plays an important role. The other modules are the teacher/learner communication module (subjectivity and diversity subjects), the educational environment instrumentation module (from computer until black board tool) and pedagogic evaluation module (from written evaluation until written reports tool). [8]-[11]

TABLE 3. MOT Modules Division under Integrative Approach.

1- Knowledge Model: Thematic Approach
2 - Teacher/Learner Communication: subjectivity, diversity, creativity, flexibility subjects
3 - Educational Environment Instrumentation subjects (pedagogic tools, methods...)
4 - Pedagogic Evaluation subjects (process evaluation and events evaluation under different evaluation tools)

The next question is about generality of MOT proposal in terms of knowledge representational model. If MOT is a generic educational proposal, it must be possible to implement MOT since beginner's level. How to deal with complex knowledge approach at beginner's level? The conceptual directives from MOT using O.-O. modelling tool, answer this question. Since beginners' level, they can be implemented a set of projects from version Zero to version N in accordance with the MOT conceptual directives, as illustrated in Table 4.

MOT directive 1 concerns a theme definition enough generic to include the global vision under complex approach. For example: Meteorological Study referring to climatic study and global sustainability. This constitutes abstract operation zero.

MOT directive 2 concerns to theme development from generic point of view from specific ones. The initial discussion creates conscience about different aspects and system values like sustainability which will stay during all life cycle of knowledge system model.

MOT directive 3 concerns to theme implementation through a sequence of projects from easy to difficult issues. It is possible to begin with just one category, for example, Meteorological station. And, then, they are developed versions until version N involving eleven categories.

MOT directive 4 concerns to profit from reusability of knowledge. As the several project versions are developed with increasing difficulty it emerges the reusability property, from O.-O. Modelling. It favours knowledge system portability and simplification.

TABLE 4. MOT Treating Knowledge Conceptual Directives facing O.-O. presupposes.

1 - Define Generic Approach to Knowledge Model (O.O. abstraction concept)
2 - Explore Knowledge Categories from Generic toward Specific Subjects (O.-O. Inheritance Principle)
3 – Develop Knowledge Categories from Easy toward Difficult Subjects (O.-O. abstraction concept)
4 – Profit from Reusability of Knowledge (emergence from O.-O. approach)

The example of MOT practical implementation refers to Meteorological Study theme represented by two stages of project version (Zero and N version). See Figure 1.

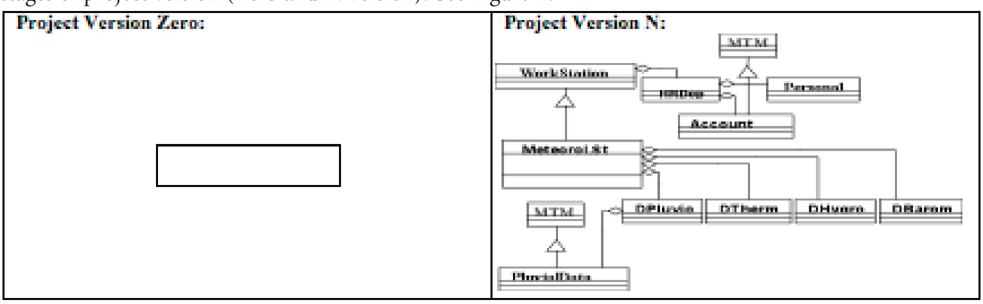

FIGURE 1. *MOT Projects Version 0 and Version N.*

Theme refers to climatic study and global sustainability (directive 1 refers to high generic knowledge approach and directive 2 refers to explore first broad aspects without implementations details). The project 'Version Zero' refers, only to just one knowledge category, Meteorological station study (directive 3 refers to abstract difficulties at first glance and increment difficulties as times goes by). The project 'Version N', includes additional knowledge categories. Besides Meteorological Station, the work station (considered a root from Meteorological station), Meteorological Station which now is subdivided into some technical departments like Pluviometric Department, Thermometric Department, Barometric Department and Hygrometric Department. Project version N points out MTM category which is a neutral environment which includes mathematical methods to be applied under theme demands (this characteristic enhances directive 4, reusability of knowledge).

It is important to reinforce the definition of a high generic level is not synonymous of a high difficult implementation. The abstraction principle (already named operation zero) is useful here to establish a set of projects versions from easy toward complicated/complex subjects. Pedagogic difference is that students can discuss, diffuse and creative way, all aspects from the big project (the generic project can also be called meta- project). It is not necessary to implement all the subjects and process at first glance. The first project, or project number zero, is very simple, it can concern just one operation over some project knowledge category, but it points out a trajectory to the project versions with increasing difficulty. This is a core curricular proposal to treat knowledge under thematic view, and to distribute curricular contents around this axis. The time life cycle of a theme is also core condition because a big cycle is equivalent to big real world projects and it is useful in education as a pedagogic approach. The integration concept is a necessity and consequence of the complex approach.

4 BPT DEGREE PROGRAM EXPERIENCE AND MOT EDUCATIONAL PROPOSAL UNDER O.- O. MODELLING TOOL

Next step is to identify in the BPT Degree Program affinities with MOT methodology reinforcing the importance of BPT concrete experience looking for the future of technological education all over the world. Table 5 illustrates several different pedagogic aspects implemented at BPT Degree Program, extracted from the mentioned ICEE workshop document, and, its classification under MOT modules (knowledge approach, communication and instrumentation, and evaluation).

TABLE 5. Comparing MOT Integrative Approach and BPT Degree Program.

MOT Educational Approach	BPT Degree Program Pedagogy
Knowledge Model under Integrative Approach	Adoption of broader knowledge model conception. (ex. Biomaterials in International and Sustainability context)
Teacher/Learner Communication and Instrumentation under Integrative Approach	Improvement of teaching methods incrementing teaching skills(ex. work in group, feedback to students, reflective journals, reports and presentations)
Pedagogic Evaluation under Integrative Approach	Improvement of evaluation methods (ex. weekly assignments replacing conventional exam)

5 CONCLUSIONS

About Knowledge Model under Integrative Approach – BPT Degree Program adopted an advanced conception in terms of knowledge model under integrative approach. For example, it includes broad conception of biomaterials instead of traditional forest products and raw materials. The concepts of internationalization and sustainability give support to knowledge vision as well the adoption of foreign language integration (English) supporting international demands. This broad knowledge vision also demands special integration between basic subjects like mathematics and professional ones. On this subject, integration since the first year of studies is favoured by thematic approach as a central knowledge axis like proposed by MOT educational methodology. It promotes what BPT Program expressed in the workshop:

"studies are clearly more motivating for students if the issues to be studied are connected with real practical working life situation or their simulation" and also "it is important to teach process of acquiring new information than to merely study a particular issue". [1] Thematic view in terms of curriculum development brings to process view under dynamic approach instead of isolated content under static approach as usual under traditional sequential curriculum.

About Communication in Teachers and Learners Environment under Integrative Approach – BPT Program has provided pedagogic training improving teaching methods and incrementing teaching skills is an important support for all educational development systems. It is expected the modification of teachers in terms of personal filter. This affects immediately learners view recognizing environment subjectivity and diversity (educational values). This way it favours emergence of creativity and flexibility (educational values). Those positive values are important to be present in professional profile facing nowadays demands. Different methods like, presentations, development of reports, work in group with different roles, development of reflective journals, and teacher feedback to students tasks, are useful to create those set of mentioned educational values.

About Pedagogic Evaluation under Integrative Approach – curricular approach added by new look of participants towards methods, tools and values, naturally affects learners evaluation. BPT Program adopted, for example, weekly assignments replacing conventional exam. This way, static evaluation view is converted towards dynamic evaluation view. And isolated event evaluations are converted in towards integrative process evaluation. MOT educational proposal supports this kind of evaluation adding it is possible to implement partially process view also under very traditional sequential written evaluation tool. In this case, it can be included open topics, like students questions instead of expected students answers, or, topics answer under visual representation instead of written text topic answer, or even, student opinion about topics and choice between several topics under preferential subjects instead of only teachers preferred subjects.

Finally, to change is a large way. It can be pointed out that new approach do not exist by itself. New approach always constitutes an evolutionary knowledge level supported by precedent ones. It do not exist new approach against traditional approach but it exists integration and reallocation of subjects and methods in a new process of time dimension allowing wider life cycle for the subject of study under thematic approach. BPT Program constitutes a positive example of integration between administration, departments, teachers and learners, to provide an evolutionary education at the present times. And potentiality of pedagogic results increases a lot under such kind of educational proposal.

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194 THE AUTOMATION ENGINEERING STUDENTS' KNOWLEDGE DEVELOPMENT IN A SIMULATED WORK ENVIRONMENT

Outi Laitinen[1], Seppo Kuikka[2] & Pekka Alho[3]

1 Tampere University of Technology, outi.laitinen@tut.fi
2 Tampere University of Technology, seppo.kuikka@tut.fi
3 Tampere University of Technology, pekka.alho@tut.fi

ABSTRACT

The automation engineering students shall be up to their assignments at work after finishing their M.Sc. degree. The learning processes during university education should thus prepare them for demanding real world design tasks. An evaluation of learning results was carried out in this study during a university level course. We utilized interviews and observations to collect data for the study. In analyzing the data we utilized content analysis. The target assignment was carried out in a student laboratory environment which simulates an industrial pulp process. Varied group profiles were identified for participants of this exercise: master and apprentice group which is well known and widely used in automation engineering, pair programming group which is well known in software engineering, and regular student group which represents the control group. One interest in the evaluation was to compare the traditional methods, master and apprentice groups and regular pairs, with pair programming which is rather unfamiliar in the field of automation engineering.

Keywords: Automation engineering, knowledge development, group learning

1 INTRODUCTION

Automation engineering is an engineering discipline the objective of which is to design and implement automated functioning of industrial processes. The output of automation engineering activity is usually a control system which governs an industrial process on various levels, ranging from basic process control to higher levels such as management of production. Current trend in the industry is to make production processes more flexible and safe. This increases the complexity of the processes and sets demands of adaptability on the control systems. Thus, also new kinds of competencies, knowledge, as well as work practices are expected from automation engineers who design automation and control systems.

Automation engineering is conducted in projects in which several stakeholders participate and which consist of several phases from initial planning and preliminary design to implementation and commissioning. Automation engineers gather information about the required functioning of the automation application from different stakeholders; for example, process design, piping design, and electrical design provide input for automation design. The automation engineers interpret the requirements and "translate" them into the language of the particular automation product. Building a control system requires thus not only knowledge of automation technology and development tools but also understanding of industrial processes and complex engineering projects.

The automation engineering students at universities shall be up to their assignments at work after finishing their M.Sc. degrees. The learning processes during the university education should thus prepare them for demanding real world design tasks (see e.g. [1]). We studied eleven automation engineering students' learning and in this paper we give answers to these research questions:

1. How does automation engineering students' knowledge develop during a practical work assignment?
2. What is the optimal form of a student group for such work related assignments?

2 RELATED RESEARCH

Stonyer and Marshall [2] have applied the ideas of problem-based learning (PBL) in learning within some of New Zealand´s engineering workplaces. They have created a PBL approach to engineering training in the workplace. This approach presents many inspirational ideas that we can take advantage of when studying the competence development of engineering students. For example, we utilised these ideas when designing the assignment used in this study.

Ahmed and Wallace [3] have studied the knowledge needs of novice and more experienced designers, working in the aerospace industry. According to their analysis of the collaboration of novice and experienced engineers, there are differences in the information needs between the two groups. The novices needed information of, for example, the functioning of equipment or the meaning of specific terminology, whereas experienced engineers needed answers to more complicated questions, such as, issues that should be considered at different phases of projects. These results were useful for us when dividing students into groups.

Also Finger's (et. al.) study [4] helped us when we were designing the assignment groups. They claim that in team based working, such as in engineering design, learning takes place most often in collaboration which increases individual learning through co-operative elaboration of thoughts and personal reflection.

3 METHODOLOGY

This study was carried out within a course ACI-21110 Batch Process Control which is part of the syllabus of Tampere University of Technology Automation Engineering degree program. This course consists of lectures, laboratory exercises, a practical work (assignment), and an exam. In lectures we presented theoretical background information about batch control according to the ISA-88 standard [5]. Batch processes are utilized especially in industries where flexible use of production equipment in producing various end products is required. Batch processes can be found, for instance, in fine chemical industry, pharmaceutical industry, and also, food and brewing industry. [6]

We categorized students into three profiles according to their credit units and working experience (see table 1). Students with less than 180 credit units were categorized as bachelor degree students (BSc) and those with more than 180 credit units as master degree students (MSc). As working experience we accepted any kind of understanding about automation design, for example, from summer job. We call these students masters (M) in this study. We utilized these profiles for grouping students into assignment groups.

TABLE 1. Student profiles.

Profile name	Description
Bachelor degree students (BSc)	- Less than 180 credit units at the end of the semester - Most have studied automation and automation engineering as their intermediate studies - None are familiar with batch control or design tools used in this assignment
Master degree students (MSc)	- More than 180 credit units at the end of the semester - Most have studied process control as their advanced studies - None are familiar with batch control or design tools used in this assignment but some of them have some knowledge about batch processes
Masters (M)	- Master degree students who have work experience in automation design (e.g. from summer job)

We had four types of assignment groups that were utilized in our study: two pair programming pairs, one regular pair, one master-apprentice pair, and one master-apprentice group (3 persons). Group forming was guided in a way that masters were guided evenly to master-apprentice groups. BSc and MSc students formed the rest of the groups. They also had an opportunity to choose which pair form they would like to use (pair-programming or regular pair).

Data was collected during the assignment process with interviews and observation. All interview and observation data was collected into a database from where it was easy to use, for example, using SQL requests. We interviewed our students three times. In the first lecture of the course we introduced the research frame. We also told them for what purposes we are using this study. They seemed to be rather interested in the study and were pleased that teachers were interested in their learning.

The first interview was after the first laboratory exercise. At this point we asked questions about the students' expectations for this course and also collected some background information. The second interview was organised after the second laboratory exercise when they had written their requirement specification. Final interview was organised as a part of demonstration in which students introduced their control applications for the course instructors. Observations were carried out during the course when students faced problems and asked for help or guidance. Co-operation between students and teachers was informal. Students consulted teachers when they faced problems in the laboratory. They also reacted naturally to teachers' visits while they were working in the laboratory. During these observations the dialog between students and teachers was also informal, no pens and papers were used during the visits. Teachers did their respective notes afterwards in their office.

The practical work assignment imitated real automation design process and was realized with a small scale physical water process which simulates a pulping process. In addition to this process we also had a distributed control system (Siemens PCS7) for automation of the process. In the assignment, students first defined and finally implemented a batch control application with control system and its design tools. The term "design tool" encompasses all tools that can be used to implement an application. There are design tools, for example, for describing physical equipment, batch control application, and user interface for the application.

As an analysis method we utilised a simple content analysis method (see e.g. [7]). First, we coded our research material by giving every statement a short code name. After that we grouped these code names into bigger groups which were also named. We observed the data from the perspective of both research questions, and thus, we found out the categories, introduced in tables 2-5.

4 RESULTS

4.1 About the knowledge development of students

We asked our students in the beginning of the course what their expectations of learning are for the course. We also asked at the end of the course what they learnt during the course. When analysing and categorising the expectations and results, we found four categories under which these answers can be divided. Those categories are design tools, batch processes, automation design, and useful skills for work. The answers are summarized in tables 2 – 5, below.

Category "design tools" describes expectations and experiments of learning focusing on the control system and its design tools used in this assignment. On the other hand, "batch processes" describes expectations and experiments of learning concerning the special process type introduced in this course. "Automation design" describes the expectations and learning results which focus on designing and design tasks. Finally, some students seemed to be interested in and had expectations and also some learning experiences dealing with the useful skills for work contexts in general.

When considering the expectations and learning results, the most analytic issues belong to table 5. In these answers the students analysed the usefulness of information they achieved from this course in their workplaces. Also table 4 contains issues which indicate some analytical thinking. On the other hand, both of the other topics (tables 2 and 3) can be found mainly from the course description, and thus, they do not require as much reasoning as the other two groups.

In all tables the notation MSc1-4 stands for master degree students, BSc1-4 for bachelor degree students, and M1-3 for students who have some work experience (the so called "masters" in this study, see table 1). In these tables the mismatch of expectations and results are printed in italics.

TABLE 2. Design tools.

Student profile	Learning expectations	Learning results
BSc1	- Knows well enough how to use PCS7	- Learnt how to use PCS7.
BSc2		- *Learnt how to draw up procedures*
BSc3		- *Learnt how to design control applications*
BSc4	- What kinds of design tools are used for automation design.	- Learnt something about design tools
MSc2	- *Have an idea of PCS7 in general.*	
MSc3		- *Learnt how to use PCS7* - *Learnt how to use procedure models in automation design*
MSc4	- Learn to use PCS7 (control system)	- Learnt to use the batch tools of Siemens control system
M3	- Have an idea how to use PCS7 because it's probably a useful skill in future at work.	- Understand what PCS7 is and how it works.
M2		- *Learnt how to use design tools*

TABLE 3. Batch processes.

Student profile	Learning expectations	Learning results
BSc3	- Have a picture of batch processes and they control principles	- Understands what batch process as a concept means
BSc4	- Attain a general conception about batches and batch production and also how these differ from others	- Learned something about batch control in general.
MSc1	- Understand better what are batch processes	- Understand precisely what are batch processes
MSc3	- Have an idea about operational principles of batch process	- Understands what actually is a ISA-88 physical model and the whole picture around the batch control
MSc4	- *Attain deeper understanding about batch processes*	
M1		- *This was the first time when I operate with batch processes*
M3	- Understand what are batch processes and how you can utilize these processes in industry - To understand the entirety of batch control	- Got a general picture of batch control

TABLE 4. Automation design.

Student profile	Learning expectations	Learning results
BSc1	- Know well enough how to utilize the ISA-88 models in practice	- Learned something about the classification principles of batch control and the integration of theory and practice
BSc3	- *Learn how to design effectively batch processes which work*	
MSc1	- Learn to use the equipment in laboratory (process, PCS7...)	- Understands the functionality of laboratory equipment
MSc2	- To understand how the design project works	- Understands the entirety: what parts belong to the automation project - Understands the significance of documentation and its updating.
MSc3	- *Learn how to design control systems*	
M1	- Have a good picture about how to automate processes in general - Learn how to design control system entirely	- Learned how to perform an automation project - Learned that good specification about the requirements and functions of system will truly help implementation work

TABLE 5. Useful skills for work.

Student profile	Learning expectations	Learning results
BSc2	- Understand the content of course and have ability to information retrieval from elsewhere	- Learnt what kind of interfaces are between recipes and physical model - Realized that applications are not necessarily implemented according to standards
BSc4		- *Learnt something about pulp processes*
MSc3	- *Have an ability to understand documents dealing with batch control (in future work)*	
M2	- Learn how to find the important parts of a process - Make the process equipment work properly	- Learnt how to perceive e.g. significant measurements and how to use the information collected from sensors
M3		- *Learnt what a pulp process means*

When considering the results and how well students achieved their learning expectations, we can postulate that all the students achieved at least partly their expectations. We did not ask them to write down their expectations in the beginning.

Nevertheless, it would be possible that the interview questions dealing with the expectations students have for the course make them analyse their reasons to take this course, and thus, helped them to formulate their learning goals for themselves. This could also have motivated them to carry on through some of the problems they faced during the assignment.

There were also some learning results that students did not expect in the beginning. For example, the design tool seems to change students' thinking significantly, as can be seen from table 2. There are several students who do not have any learning expectations from this field but still have some learning experiences from it (students BSc2, BSc3, MSc3 and M2). Thus, almost all students (9 out of 11) seem to have some kinds of learning results related to design tools when only five had expectations in the beginning. Also two of the students realised in the end that they have now a basic understanding about pulp processes even though that was not the purpose of the course.

In general the learning results are more concrete than learning expectations. We believe that this indicates learning occurring when a rather superficial idea of possible learning expectations have transformed into true understanding. Also insights indicate that learning has occurred. These kinds of insights are, for example, in table 5 those learning results introduced by students BSc4 and M3 who realized they understand something new about pulp processes.

4.2 About the optimal form of a student group

There were four types of groups we utilized in this study: two pair programming pairs, one regular pair, one master-apprentice pair, and one master-apprentice group (3 students). With pair programming the working habits of pairs and regular pairs in the laboratory environment were fairly similar, for instance, one student operated the process computer. With pair programming pairs the other student read instructions and specifications while keeping an eye out for operator errors. In our interviews the students considered this to be the natural way of doing things. With the regular pair the non-operating student was not always actively following what was being done at a given moment. This made it harder to understanding what was going on, whereas with pair programming pairs the students reported that they were following more actively what was happening.

The smaller master-apprentice group reported that their working habits in the laboratory were similar to a regular pair before the apprentice had to interrupt the course for external reasons. The three person master-apprentice group had some trouble fitting the working times with the time tables of each others, and in the end they were doing lab work also in pairs.

Despite these minor obstacles students faced during their projects, the master-apprentice groups found the work experience of the masters useful, especially in the definition phase of the assignment, and generally speeding up the assignment as well. Master-apprentice group members considered this group form to work well, as long as the motivation of the apprentice is sufficient and he/she utilizes the chance to learn, instead of leaving all the work for the more adept master. Masters noted that this form requires some willingness to teach but in return the master can also learn by teaching. Overall apprentices were happy to have an experienced pair and masters were pleased with the diligence of apprentices.

The level of understanding students achieved during the course was evaluated based on the interviews, assignment and exam results. This was compared between group profiles to assess the effects of group form on learning. Master-apprentice groups had best performance in exam, assignment and understanding of automation. Pair programming pairs had second best performance in the same categories. Regular pair had the best understanding of the process.

Overall the students were happy with the group forms they had, including the regular pair who liked the freedom to choose the working methods by themselves. Interview answers about how the different group forms worked were along the line “pretty well – very well”. When asked about what group form students would have liked to use, most of them were content with the form that they had used.

5 CONCLUSION

We studied our research material from knowledge development perspective and group type perspective. When considering how well students achieved their learning expectations, we can postulate that all the students achieved at least partly the expectations. In general the learning results seem to be more concrete than learning expectations. We believe that this indicates that learning occurs when ideas of possible learning expectations have transformed into true understanding. From group perspective, on the other hand, master-apprentice groups had best performance in exam, assignment and understanding of automation. Pair programming pairs had second best performance in the same categories. Regular pairs had the best understanding of the process.

As far as we can see, this was first time when automation engineering students' learning was studied in such an analytical way at Tampere University of Technology. The syllabus of Automation Engineering degree program is under reform process at the moment, and thus, the results presented in this paper will be - on their part - useful when designing new courses and new assignments for our students. On the other hand, the results may not be comprehensive enough in the sense of scientific relevance due to the small amount of students. Nevertheless, the research frame used in this study is interesting and easily adaptable for larger student groups, too.

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195 ENGINEERING PROFESSIONAL DEVELOPMENT AND ECONOMIC GROWTH: ISSUES OF COLLABORATION BETWEEN ACADEMIC, INDUSTRY AND PROFESSIONAL ORGANISATIONS FOR THE BENEFIT OF EMPLOYMENT AND SUSTAINABILITY

James Uhomoibhi[1] & Margaret Ross[2]

1 University of Ulster, Faculty of Computing and Engineering, Co Antrim BT37 0QB, Northern Ireland, UK, j.uhomoibhi@ulster.ac.uk (author for correspondence)
2 Southampton Solent University, Faculty of Technology, East Park Terrace, Hampshire, SO14 0RD, UK, margaret.ross@solent.ac.uk

ABSTRACT

The paper discusses the practical issues of integrating professional and industrial qualifications with academic courses. The authors have practical experience in integrating professional qualifications with degree courses. The paper examines the processes involved in engendering useful collaborations for the development of systems and qualifications for attainment of qualifications and competencies useful for employment. The paper reports on existing partnerships between organisations with a focus on professional computing qualifications from BCS, the Chartered Institute for IT. An example of setting up such a combination of academic and professional qualifications is provided. This is done in relation to specific roles and initiatives of professional bodies, expectations of industries and the aspirations of learners for a sustainable future.

Keywords: STEM, ICT Professional Qualifications, Academic, Professional, Industrial collaboration, continuing professional development

1 INTRODUCTION

Today more than ever there is a full realization to meet training needs of students and employees in businesses through joint ventures such as graduate programs (degree and certificate) and professional development activities (customized classes, seminars, forums, and conferences). In the current global economy, the STEM students need to be able to demonstrate to potential employers, that they possess extra competences. In addition to the technical skills covered in traditional degree courses, Opportunities exist to enhance them. Various actions by universities are possible, including closer links with local industries, by visits, visiting lecturers, industrial based projects and placement opportunities. The placement is where the students could work for an organisation for up to one year, usually after spending two years on their degree course, then returning to the university after the placement for the final year.

Further action can be taken in conjunction with professional bodies, such as the BCS, the Chartered Institute for IT, the Institute of Physics (IoP), the Institution for Engineering and Technology (IET), the European Society for Engineering Education (SEFI) etc., by encouraging the students to achieve professional qualifications, in addition to their technical degree awards. The industrial or professional qualifications could be of particular interest to employers who are not directly aware of the particular university courses when they are located at a distance or in a different country. These professional qualifications are developed in direct association with the relevant industries.

By introducing students to these qualifications, external to their universities' assessment process, the students should have developed their confidence to be able to maintain their continuous professional development to an approved level, by taking further external qualifications throughout their working life. In the STEM disciplines, the need to update the skills is essential. By introducing students to the professional bodies and their qualifications, and also those of organisations, such as the Microsoft and the Cisco qualifications, students have more confidence in planning and organising their future continuous professional development.

2 CURRENT TRENDS AND DEVELOPMENTS

Recent developments have include some formal collaboration between a university (or group of universities) and an industry organization (or group of organizations, especially in engineering, directed at meeting critical employment education and training needs of students and employees through joint ventures such as graduate programs (degree and certificate) and professional development activities (customized classes, seminars, forums, and conferences).

Studies have shown some achievements with Industry/University collaboration helping to close the gap between industry and academia [1] featuring three of the efforts of the model for collaboration. There are some key question that have to be answered such as Why do we need to collaborate? What are the benefits of collaboration? How could collaboration be started and operated to yield results? and what makes collaboration successful and sustainable to ensure economic continuing personal and professional development and economic growth in the face of current globalisation?

In today's world of ever-changing industrial environment worldwide, the update of knowledge and skills has become a necessary professional development strategy for employees to ensure that they are equipped with the necessary skills and capabilities for employment [2, 3].

Besides the placements for students, professional development has been advocated across continents, notably in Africa and Europe where employers are encouraged to provide opportunities for industrial attachments for trainees as well exchanges for teachers [3, 4]. We continue to see interaction between universities and industries in a bid to address skills need for economic growth and well-being of businesses.

3 THE RELATION OF PROFESSIONAL QUALIFICATIONS TO ACADEMIA

Universities and colleges can include, sometimes at the students' own expense, the opportunity to take external professional qualifications, such as those by Cisco and Microsoft. The ECDL (European Computer Driving Licence) and the ICDL (International Computer Driving Licence) at the initial level of end user computing competences can be offered to students, often in the first year of their degree course. As these assessments are normally via the Internet, there is no restriction of location or country, providing the necessary technology is available.

Further on-line assessed qualifications are offered by the BCS, normally based at the foundation level which is operated by their ISEB (Information Systems Examination Board) [5, 6]. Many of these qualifications can easily be associated with taught elements of an ICT degree course with very little modification to the degree syllabus and assessment structure. Most of these could be taken after two or three years of the ICT degree. An example of this is the Green IT Foundation qualifications [7].

One of the countries with highest take-up of these on-line multi-choice qualifications is India. With the increase in concern about the risks associated with ICT, the new BCS e-security qualification is designed to provide an independent assessment of the candidate's knowledge in this area. The topics of similar ICT qualifications range from analysis and design to an in-depth understanding of the work of the EC Code of Conduct for Data Centres [8, 9]. All of these qualifications are of use to BCS Members' (both within and beyond the UK) as well as non-members, whether in industry or academia.

4 THE TYPICAL PROCESS

The authors have had considerable practical experience in integrating professional examinations with full time and part time degree courses [10, 11]. They have found the following procedure was normally successful. First it is necessary to gain the approval of the Head of the Department, the Course Leader, the relevant lecturers and the university´s Quality Assurance Department. It is normally necessary to adjust the syllabus, but ideally the professional qualification should be partly or completely relevant to a particular unit or module. Modifications to the syllabus have to have the approval usually of the university and in the UK, the External Examiners of the course. It is often necessary to slightly alter the assessment, both in timing and in style in order to be similar or complementary to that of the professional examination. Sometimes it is necessary to obtain the recognition of the professional body. An example of this was when permission was granted by the BCS for the SSADM (Structured Systems Analysis and Design Methodology) course and examinations to be offered at Southampton Solent University. It was necessary to provide examples of the course material. As this was a new course, it was more efficient to obtain the copyright agreement to use material developed by the NCC (National Computing Centre) for that particular examination, which was then modified and expanded by the author, Ross. This made it easy to show the full coverage of the professional syllabus. It was also necessary to provide documentation about the organisation and structure of the university, including the quality assurance, student support and representation and the care of able bodied and disabled students. An inspection was made of the university. The experience of the lecturers who would be involved with the course was considered. If the professional qualification involved the use of laboratories, these would have been visited.

Once agreement has been obtained from both the university and the professional body, it is necessary to make the arrangements which have to be made for the professional examinations including the timing of the examinations. In the example of the SSADM examination, the timing was set regularly a few weeks after the full-time and part-time students had taken their course′s unit examinations, which were different, but of a similar style and difficulty. Those students that passed the university's examination, were allowed to take the professional examination, at their own expense. A very intensive two week course to prepare external computer professionals was always organised prior to the examinations, so both the internal and the external candidates took the examination together.

In some cases, in addition to written, unseen examinations, the students might have a practical and an oral examination. In the case of the SSADM course, the day following the written examination, those students that had passed, had an oral examination. In the case of the SSADM qualification, the examination paper was set externally by special BCS examiners. The lecturers did not see the questions until the envelope was opened in front of the candidates, and the examination papers were distributed to the candidates at the start of the examination. The Southampton Solent University always held the SSADM examination on the Thursday morning, so that, while one lecturer could prepare the candidates for the viva during the Thursday afternoon, the other lecturers involved with SSADM would double mark the candidates' examination scripts, using the marking scheme provided by the BCS. On the Friday morning, the two external examiners would moderate the marking of the scripts, then the examiners would give each candidate in turn their oral examination. The questions to each candidate would vary, depending on any area of weakness demonstrated in that candidate's examination script. After the external examiners had left the university, the candidates were given their results. The University runs a similar process. In the case of some CPD qualifications there exist the option of online mode of study and assessment.

4.1 Course Offering and Industrial Contributions

Collaboration has a lot to offer present students and employees in industries in terms of engineering education and training activities. Some of these include classes, seminars, conferences, workshops, and certificates and degree programs. These activities are typically held on location, either at the university or industry site and could vary depending on circumstances and learners' conditions. Some of the advantages of such programmes lie in the variety of formats used in content delivery such as practical hands-on seminars, use of distance learning technologies and e-learning, and formal classroom instruction.

4.2 Models and Benefits of Collaboration

The models of collaboration used by universities include

- Single university-single industry collaboration where a institution provides education service (degree or certificate) to employees of a single company.

- Single university-multi-industry collaboration where a university provides tailored training and qualifications to employees of more than one company with whom it is collaborating.
- University-consultant collaboration where an institution partners with a consultant to jointly deliver accredited training certificate programmes as well as short courses in specified areas to learners and employees from companies.

In all cases they serve to enhance institutional reputation, expand portfolio of provision, provides access to affordable research, training, and educational resources from industry partners. Collaboration among teachers and students giving rise to collaborative teaching and learning has a lot of benefits for students, teachers, institutions and the sectors. Extensive studies have proven collaborative learning as the best form of learning. Research has shown collaboration creates opportunities for reflection on learning processes and new experiences. It adheres to holistic perspective on professional development [12][13].

5 COLLABORATION IN TEACHING AND LEARNING AND BETWEEN EDUCATION, INDUSTRY AND THE PROFESSION

Education institutions, professional bodies and business organisations have a strong desire to understand the relationship between world of work and the world of learning. The efforts are directed not just at the dynamics we unpack and gaps identified for bridging but also at the effect and power of settings, policies and development for employment, teaching and learning.

5.1 Collaboration Design and Experiences

The collaboration often entails contributions from all partners, that is participants from the institutions and places of employment. Courses developed from such a process are usually up-to-date, pragmatic, interesting and fit for purpose in terms of content and pedagogy. Both the developers and learners often end up satisfied with outcomes. The effect on teacher practice, business and economic growth is positive and does promote creativity and innovation needed for stimulating engagement and broadening the thinking landscape for everyone involved in the process. Students become interested and keen to learn what they are being taught. The challenges that must be addressed include having to find a time suitable for all participants to meet, building consensus, and overcoming policy issues in practice which may not have catered for cross-organisational partnerships and collaboration.

5.2 Views of Students and Staff

At Southampton Solent University, the relevant students were able to take the SSADM, ECDL and Cisco qualifications. All those students were very proud of having passed professional examinations. They felt that this was very important for their CV, especially if they had no relevant work experience. Many of the students reported that when they had been interviewed by potential employers, the employers usually asked more questions relating to the professional qualifications than about their degree course. By taking these additional qualifications, it apparently showed that these students were particularly enthusiastic about their subject. As the employers usually know these qualifications, they were able also to understand in detail, what the students had learnt and their ability in that area.

The lecturers, who were involved with these professional or industrial qualifications, all felt that this benefited their CV, especially when full-cost intensive courses were also organised for these qualifications. As the syllabi for these qualifications are either controlled or produced in conjunction with industry, the syllabi are kept up to date. This ensures that the lecturers′ knowledge of their subject is also current. This in turn benefits other students who are not involved in these professional or industrial qualifications.

5.3 Suggestions and Skills Development of Future Workforce

It is a suggestion from our present study that institutions, business organisations and professional bodies work in partnership to develop and deliver a well rounded package of learning to equip the present student and workforce of today and the future with the necessary knowledge and skills required to engage successfully with the world of work . The design of what should be covered could be jointly developed as is presently being practiced with BCS, the Chartered Institute for IT and the universities cited in this report (Southampton Solent University and the University of Ulster in the UK) and involvement of industry to inform education on what the needs of the sectors are in designing curricula for students engagement.

Globalisation and life of the 21st century dictate that a variety is skill is required for any given work such as the use of computer mediated communication tools and associated techniques as well as the ability to apply a combination of the traditional processes in the workplace.

5.4 Networks formation and interaction for Enhanced learning

It is a belief that an important aim of university education is to encourage students to take responsibility for their own learning and to promote close interaction between professionals in training. Students should be encouraged to engage in lifelong learning (a skill sought after in computing and engineering). Lifelong learning is the ability to maintain currency with developments and progress in a chosen field of expertise. Collaboration is key to success of very large engineering undertakings.

The building and use of networks that allows for peer interaction, per instruction and peer mentoring should be explored. Such networks have the benefits of promoting collaborative learning links among students, engenders students to take responsibility for their own learning, gaining confidence and engaging in home study and lifelong learning all of which enhances professional development and allows for sustainable development necessary for economic growth.

6 ISSUES OF CULTURE, PRACTICES AND CHALLENGES

There are so many factors that are important ingredients in learning. Some of these include language, students' relation to the dominant culture and motivational state of the learner [14] [15]. Details of other factors have been reported by Falk et al.[16]. The importance of the styles and approaches to learning have been investigated. Some of these include amongst others, the structuring of knowledge; the role of social interaction; mediating experiences and devices and the institutional meaning attached to learning. There are instances where the culture of learning may differ. The problem of defining the difference remains crucial and vital to be resolved. It need not be based solely on location [17].

We can perceive learning as a cultural practice, a process, for which tools are required to analyse and understand. Globalisation has had a firm influence on how universities in different countries and packaging learning and on how businesses are taking decisions on what skills they require and how well what work is done goes to facilitate economic growth which over the past few years have been seen to be experiencing some difficulties.

7 CONCLUSION

Collaboration involves shared goals, planning, mutual trust, effective communication, high level of understanding, patience and hard work. Engineering education and training issues require a hybrid type of arrangement and organisation with the capability to address and act upon the elements of any situation in a timely fashion. Collaborations offer a structure, dialogue and action format for addressing the dynamic education and training needs of engineers.

The need to maintain and to prove professional competence is required by many organisations and professional bodies. For example, a Chartered Scientist (CSci) has to present evidence of current activities every year to retain their chartered status. A number of States in the USA are introducing a licensing scheme for IT consultants [18] who wish to work for the Government organisations. In future IT professionals may have to be members of approved professional organisations in order to practice, as lawyers, accountants, doctors etc are currently required to be. The benefit of introducing students, while at university, to the relevant professional bodies and professional and industrial qualifications should be of use to the students throughout their careers.

We conclude that students and employees' knowledge and skills update including academics and professionals could benefit through industrial attachment and programmes of collaboration. Such initiatives have the potential to enhanced professional competence in the sectors and provide models of best practice directed at professional development, improved productivity, economic growth and sustainability.

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