Effective and Practical Use of Virtual Worlds and Game Based Learning for Engineering Education

MJ.Callaghan, K.McCusker, J. Lopez Losada, JG.Harkin & S.Wilson
Intelligent Systems Research Center
School of Computing & Intelligent Systems
Faculty of Computing and Engineering
University of Ulster, Magee Campus
Northern Ireland, UK
mj.callaghan@ulster.ac.uk

Abstract

In recent years there has been significant growth in the use of virtual worlds for e-learning. These immersive environments offer the ability to create complex, highly interactive simulations. Video games have entered the mainstream as an increasingly popular entertainment format. Virtual learning environments' support teaching and learning in an educational context, offering the functionality to manage the presentation, administration and assessment of coursework. The gamification of education, where game play mechanics are used for non-game applications is growing. This workshop will introduce the Engineering Education Island and Circuit Warz projects and will demonstrate how immersive virtual worlds integrated with virtual learning environments can be used effectively for a game based approach to teaching electronic and electrical engineering using a collaborative, team based competitive format.

1. Introduction

The gamification of education, where game play mechanics are used for non-game applications is growing. This workshop discusses the suitability of virtual worlds for educational and teaching purposes and will demonstrate how virtual world platforms e.g. Opensim could be used to rapidly prototype simulations to teach advanced electronic/electrical circuit theory, through a game based learning experience in a 3D immersive world, where teams of students work together collaboratively and competitively to bias electronic circuits.

2. Game based learning in virtual world's

Gamification is a term used to describe the application of video game mechanics to non-game processes in order to improve user engagement. This type of game based learning is increasingly been used in educational settings and is widely predicted to become mainstream in the next 3-5 years [1-3]. In this context the Circuit Warz project was conceived with the overall objective to investigate if creating a compelling, engaging, immersive team based game, which facilitates collaborative and competitive group interactions to teach electrical and electronic theory and principles would increase student engagement. An Oscillator circuit was chosen to develop a prototype as it is possible to get a variety of output values from the circuit using any number of resistor/capacitor combinations. This level of flexibility allows the creation of game based on generating specific output values depending on circuit biasing. The game format is time limited/based where teams of students compete against other teams to bias an oscillator to achieve a pre-defined output randomly generated by the system i.e. peak to peak voltage and period of the waveform. The winners of the competition will be the team that can successfully and practically apply circuit theory to select individual resistor and capacitor values to achieve the pre-defined circuit output. The additional novelty of this demonstration is the fact that is it linked to real hardware and the teams are working with actual physical circuits (figs 1 - 7). The scoring system is based on the formula given in fig. 8 while fig. 9 shows the team interactions and entire process recorded back into Moodle for subsequent review and analysis.

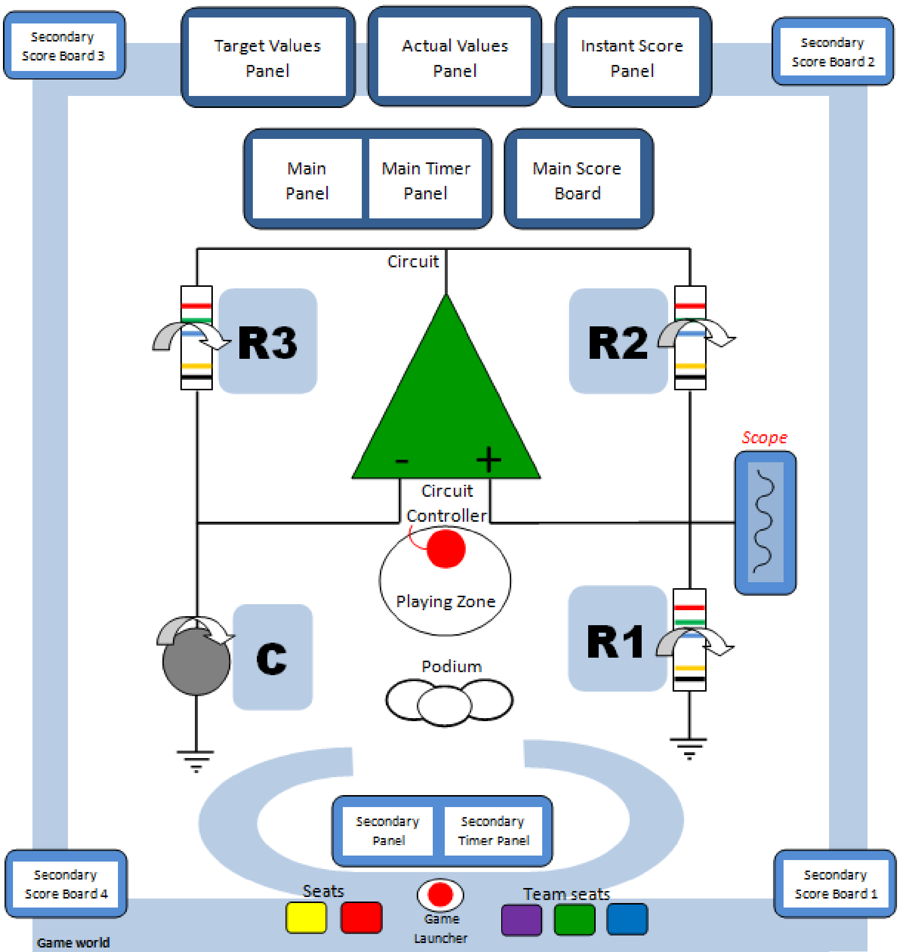

Figure 1 Oscillator circuit realized as a game

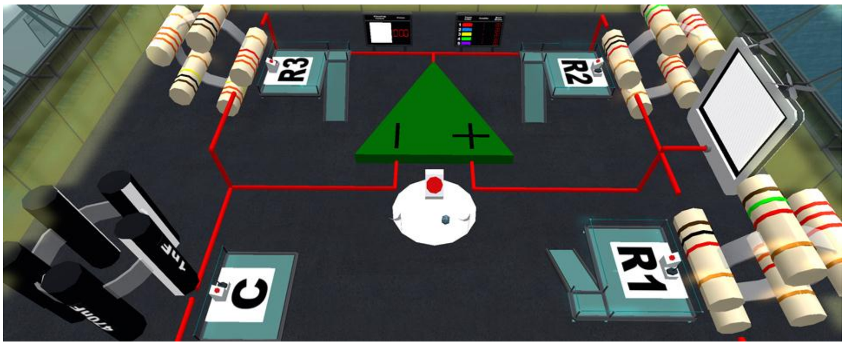

Figure 2 Virtual circuit/arena in virtual world

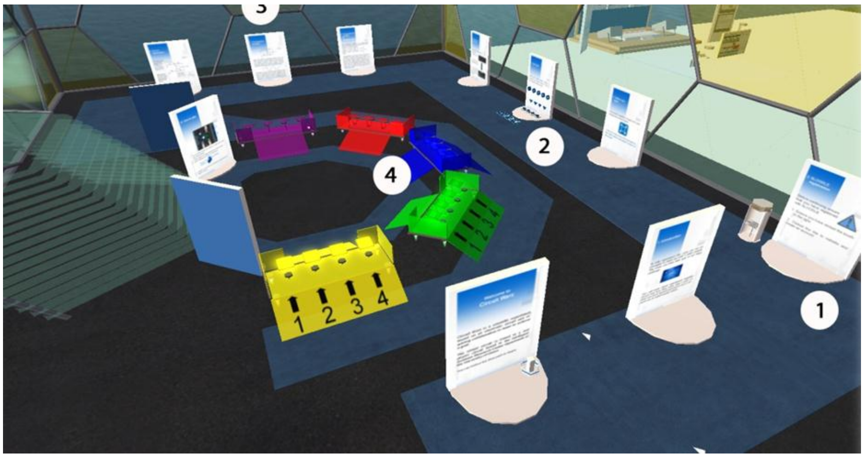

Figure 3 Overview of learning zone

R1 (Ω)	R2 (Ω)	R3 (Ω)	C (nF)	Vpp (V)	Freq. (Hz)
1000	2200	3300	47	5.5	4695
1000	2200	3300	100	5.5	2353
1000	3300	3300	47	4.125	6390
4700	3300	3300	470	10.5	218
3300	1500	3300	22	12.312	3731

Figure 4 Possible resistor/capacitor combinations and output values.

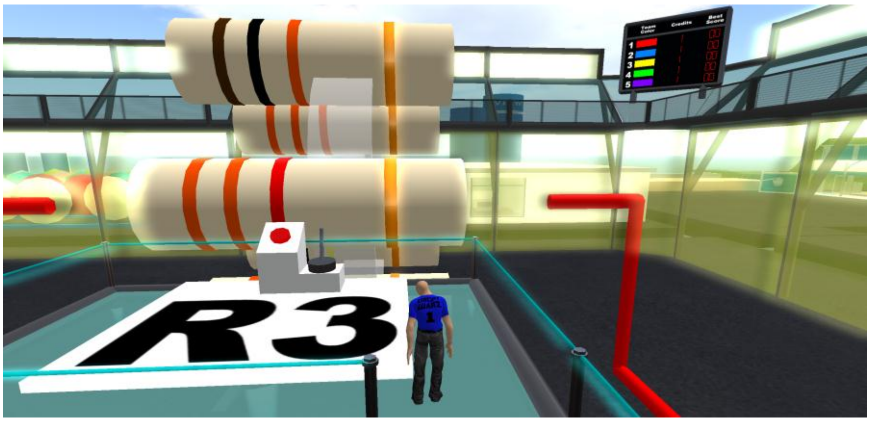

Figure 5 Resistor value selection

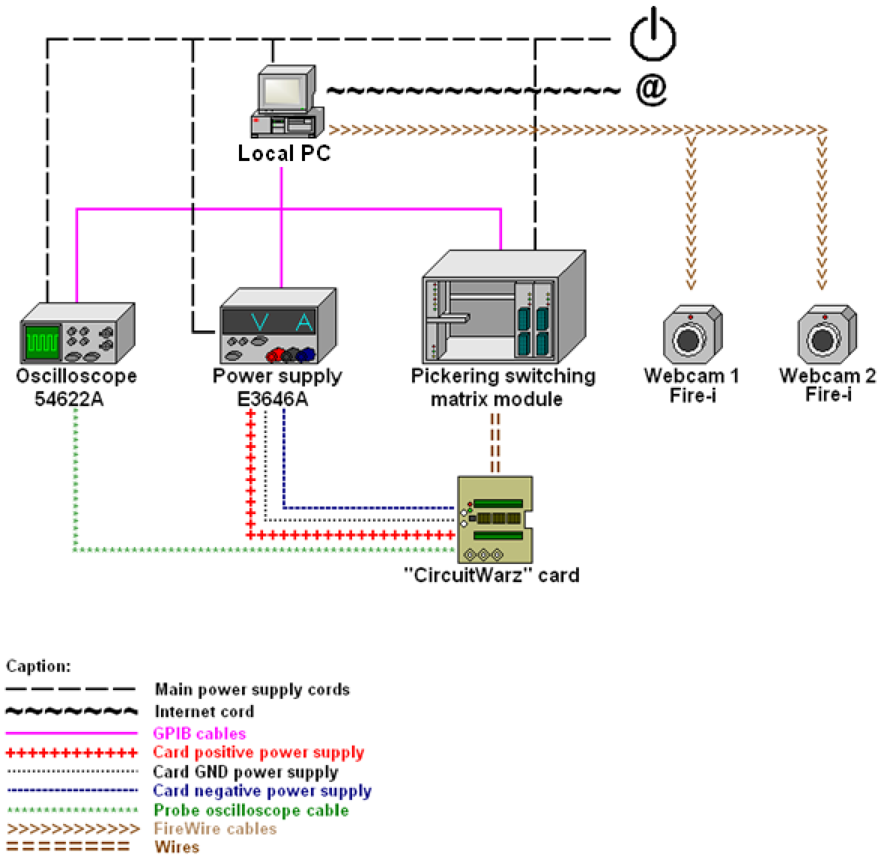

Figure 6 Architecture of the physical hardware

Figure 7 Physical circuit infrastructure

$$Score = 100 \times (\alpha \times Frequency\_percentage + (1-\alpha) \times Vpp\_percentage)$$

$$Frequency\_percentage = \frac{Min(Target\_frequency,\ Achieved\_frequency)}{Max(Target\_frequency,\ Achieved\_frequency)}$$

$$Vpp\_percentage = \frac{Min(Target\_Vpp,\ Achieved\_Vpp)}{Max(Target\_Vpp,\ Achieved\_Vpp)}$$

Figure 8 Scoring mechanism

r (Avatar)	Third Member (Avatar)	Fourth Member (Avatar)	Created in	Quiz mark (/20)	Score (/100)	I
	Alexi Marville (Alexi Marville)	Florent ARLINGTON (Florent Arlington)	August 27, 2010, 11:45 am	8	97	
D (Fabian an)	syl20 rocket (Sylvain Swords)	Demil Mares (Demilmares Overland)	August 27, 2010, 11:49 am	7	75	

Figure 9 Team interactions recorded in Moodle/SLOODLE

3.Conclusion

This workshop provided an overview of ongoing research at the Intelligent Systems Research Center, University of Ulster, Northern Ireland into the use of virtual worlds for teaching engineering related subject. The Circuit Warz project was introduced/demonstrated showing how it is possible to create a game based approach to teaching engineering using a team based collaborative/competitive format.

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National Network of Centers of Innovative Academia-Industry Handshaking: From Critical Computing to Safety Engineering

[1]A. Boyarchuk, [1]V. Kharchenko, [2]C. Phillips

Department of Computer Systems and Networks,
National Aerospace University "KhAI", Kharkov, Ukraine, tempus@khai.edu[1];
Faculty of Science, Agriculture and Engineering,
University of Newcastle upon Tyne, Newcastle, UK, chris.phillips@ncl.ac.uk[2]

Abstract

The objective of the abstract is to present the ongoing EU-funded Tempus project "National Safety Engineering Network of Centres of Innovative Academia-Industry Handshaking" (SAFEGUARD) coordinated by University of Newcastle upon Tyne. The key goal of the project is to produce new generation of engineering and research staff capable of performing constructive development in safety engineering [1]. This outcome will contribute to satisfying the needs of enterprises and institutions of different critical domains and partner country regions.

1. Introduction

Ukraine is one of the top 7 world countries when measured by the number of working nuclear reactors, and one of the 7 countries which have a complete cycle for the development of aerospace techniques. In addition, Ukraine has developed oil and gas transport, railway transport and other complex infrastructures. These infrastructures define its industrial status and, of relevance here, relate to safety critical applications. This fact is confirmed by the set of approved National Programmes on the development of nuclear energy, the space industry, and railway transport development, where safety insurance is one the key aspects. Reconstruction of Ukrainian gas pipelines within the latest agreement with Brussels, the development of auto transport and air traffic communications in line with EURO-2012, and the introduction of new generation e-medical systems are among the state priorities for the coming years.

A significant number of all emergency accidents and catastrophes are caused by faults of IT systems. Every fifth fault of space exploration is caused by the failure of computing management systems, which is mirrored in railway automation, medical radiology systems and other social-oriented applications. The importance and achievement of minimizing such risks for different safety critical systems has led to the introduction of new terms and a whole new subject area called Safeware (Prof. Nancy Levenson, leading NASA expert). The concept of safeware means the integration of the tasks of analysis and safety assurance as a single complex enitity, taking into consideration the hardware, software and human-based components of the target objects. This special engineering direction is identified by the name of safeware engineering.

The aim of this paper is to outline the contents of the project and has the following structure: section 2 presents the background and principles of the project development, section 3 gives a brief description of the consortium partners, and section 4 presents the project outcomes and activities. Section 5 summarizes the outcomes of the project.

2. Background and Principles

2.1 Background

There are a large number of enterprises and industries successfully working in the area of safety critical systems for nuclear power plants (NPP), aerospace technologies, transport, oil and gas communications in all regions of Ukraine.

Odessa and the Odessa region is the most important international transport gate between Asia and Europe. Odessa Airport (to be reconstructed for EURO-2012), Odessa railway, international pipeline “Odessa-Brody”, passenger and cargo sea ports – “Yuzhniy”, Ilyichevsk and Odessa – all these powerful transport infrastructures are being equipped with modern computing equipment and therefore need well-trained specialists in IT-safeware. A similar situation exists in Crimea and the Southern part of Ukraine. A trade-industrial complex is to be developed in the area of the Sebastopol deep-water bays. The development of an international life-saving centre for the Black Sea is also underway. The economic development of Podolie, and the Western regions of Ukraine, emphasize the importance of the installation and maintenance of hardware complexes for critical applications, as well as the need for professional personnel and well-skilled academic staff. In the Poltava region and Pridneprovie the industrial infrastructures using of composite principles of management and decision making have been created: oil and gas production, processing and communications. The needs of this region require specialists in the areas of safeware engineering, design reliability and IT-infrastructures.

Last not least, the Eastern part of Ukraine, in particular the Kharkov region, has a comprehensive set of heavy-machinery enterprises for NPP, aviation, and space exploration. The Central regions of Ukraine need specialists for corporate information-analytic and management systems which belong to the class of safety and business critical systems (health, banking, e-science, etc).

Thus it can be said that there exists a high and increasing demand for professional staff level, improvement of teaching and language skills, professional development and maintenance, and special facilities and infrastructures.

2.2 Existing Problems

For the successful decision of the described problems in functional safety and safeware IT-engineering as a whole it is extremely important to combine related efforts in education, research and engineering. Some positive achievements have already been made. But the problem is that in Ukraine and other post-Soviet countries the educational process in safeware engineering is far behind the scientific and industrial processes.

Currently the subject area of safeware engineering is completely absent from BSc and MSc programmes of Ukrainian universities. The MSc programmes on “Safety in life activity” and “Systems of ecological and economical monitoring” describe the separate parts of these problems but the approach is fragmental and non-systematic. On the other hand no single specialty on computing engineering covers aspects of functional safety and modern technologies of computer-based critical systems, as well as procedures of safety assurance at all stages of the life cycle of different products. The learning laboratories, computer, network and multimedia equipment, software and hardware resources are not suitable for the educational processes in the described specialties due to the absence of specialized software applications and hardware complexes for dependability and safety assessment of oil and gas production, oil and gas communications, NPP, and traffic management systems.

These problems are common to most of the regional universities. In addition there are a number of specific problems for each region: an urgent demand for the facilitation of the training of lecturers on general safeware-based courses (Poltava National Technical University, Sevastopol National Technical University), familiarization with the details of different safety critical systems (KhAI – for maritime, oil and gas production, Khmelnitskiy National University – for aerospace and NPPs, Odessa National Polytechnic University – for health and business critical systems, etc.).

2.3 Development of Proposal

This project proposal is a direct outcome of previous cooperation among consortium members. The idea of developing a project on safeware engineering was generated during the November 2008 academic development visit of delegation from National Aerospace University (KhAI) to Newcastle within EC-funded Tempus JEP 26008-2005 (local KhAI leader Prof. Vyacheslav Kharchenko and coordinator Dr. Chris Phillips). The idea was elaborated further during the study visit to City University and Newcastle in March 2009 where the representatives of KhAI and Khmelnitskiy met with their British counterparts. ADELARD LLP was invited to the project by Newcastle after a series of meetings within EBRD-funded projects on risk assessment activities. The University of Napoli, Italy has a wide portfolio of technical-intensive master courses including safety. Ukrainian academic and non-academic partners have joined the consortium to cover all regions and all major critical domains on safeware engineering.

3. Consortium Partners

3.1 Selection of Partners

This national Tempus JP application is submitted by the consortium of partners from Ukraine, UK, Sweden, Finland and Italy. It consists of experienced and dynamic partners, which have the necessary knowledge and skills in the subject area and the necessary capacity to implement the project and produce the expected outcomes. The project proposal has become the result of joint work of the partners and the final project proposal reflects inputs from all of them. Ukrainian academic and non-academic partners have joined the consortium to cover all Ukrainian regions and all major critical domains on safeware engineering: Critical Domains = {nuclear power plants; oil and gas industry and communications; aerospace; air traffic; maritime; power industry; e-health and medical systems; railway and automotive transport}; Partner Country Regions = {West; Center; South-West; South; East}.

3.2 European Partners

The University of Newcastle upon Tyne (NCL) can trace its origins to a School of Medicine and Surgery (later the College of Medicine), established in Newcastle in 1834, and to Armstrong College, which was founded in the city in 1871 for the teaching of physical sciences. The University of Newcastle upon Tyne is a popular university with an excellent pedigree in research and teaching and is closely integrated into the economic, cultural and social life of the North East of England. Research income from grants and contracts reached £81,600,000 in the year 2008-2009. In the 2008 Research Assessment Exercise the University entered 38 subject areas, spanning medicine, the sciences, engineering, humanities and the arts.

Åbo Akademi University (ABO) is the only Swedish-language multidisciplinary university in Finland. ABO comprises seven faculties: the faculty of Arts, the faculty of Mathematics and Natural Sciences, the faculty of Economics and Social Sciences, the faculty of Chemical Engineering (Technology), the faculty of Theology, the faculty of Education and the faculty of Social and Caring Sciences. ABO is committed to research and research-based education of the highest quality. The university offers both undergraduate and postgraduate studies and extensive research opportunities to some 8000 students. The Centre for Reliable Software Technology (CREST) is a research centre within ABO and the Turku Centre for Computer Science (TUCS).

The University of Naples (NapU) traces its origins to an act issued by Frederick II Hohenstaufen, King of Sicily and Head of the Roman Empire, on June 5th, 1224. Hence, it is one of the most ancient non-religious academic institutions in the world that since 1987 bears the name of its first promoter. The Faculty of Engineering is composed of 19 Departments and offers 16 Curricula, accounting for a population of 17,000 students.

The Centre for Software Reliability (CSR) is an independent research centre in the School of Informatics at City University, London, founded in 1983. Its scope now covers various aspects of system dependability. Most of CSR's research has been supported in recent years by funding from the UK EPSRC (Engineering and Physical Science Research Council) and the European Union through the Framework Programmes. CSR is one of the world's major players in dependability research, especially in the areas of quantitative assessment and of diversity, an area it entered in the 1980s.

Royal Institute of Technology (KTH) is the leading engineering university in Sweden that accounts for one third technical research and engineering education capacity at university level in the country. Education and research cover a broad spectrum – from natural sciences to all the branches of engineering as well as architecture, industrial engineering and management, urban planning, work science and environmental engineering. In addition to the research carried out by KTH’s Schools, a large number of both national and local Competence Centres are located at KTH. Kista Science City is the center for ICT in Sweden and is ranked as the centre for innovations in telecommunications in Europe and placed among the top-five in the world.

The Institute of Information Science and Technologies (ISTI) is an institute of the Italian National Research Council (CNR). ISTI was constituted in September 2000 as a result of a merger between the Istituto CNUCE (CNUCE-CNR) and the Istituto di Elaborazione dell’Informazione (IEI-CNR). The Institute became fully operational in 2002. The Institute is committed to producing scientific excellence and to playing an active role in technology transfer. The domain of competence covers Information Science, related technologies and a wide range of applications.

Adelard LLP (ADELARD) is an independent specialist consultancy founded in 1987. Its mission is to provide an exceptional standard of consultancy, backed by an internationally recognized research programme. It works primarily in the area of computer-based safety-critical systems with some important exceptions in our work on security, corporate memory and software reliability. Airbus, British Energy, EADS Space, Network Rail, European Commission are among the corporate clients of ADELARD.

3.3 Ukrainian Partners

Sebastopol National Technical University’s (SebNTU) is the largest technical university of Southern Ukraine. The student body comprises 11.000, the academic staff is more then 770 persons, including 50 full professors and 250 associate professors. Bachelor and master studies are given in 24 specialties. The Department of Cybernetics and Computing (CAC) teaches the bachelors and masters programmes on computing engineering within the specialty “Computer systems and networks”. Critical domains: {maritime; power industry}.

Odessa National Polytechnic University (ONPU) was founded in 1918 and changed from a technical institute to one of the biggest and well-known national universities. It consists of 12 faculties and institutes, which employ more than 1000 academic staff and teaches 13000 fulltime students. This university is the largest technical university of Southwestern Ukraine. Starting from 1969, the Department of Intellectual Computer Systems and Networks (ICSN) has taught students for the specialty “Computer Systems and networks” for the Ukrainian, Russian, Chinese, Indian markets. This educational and research direction are supported by the Departments of Nuclear Power Plants, Transport and Robotic Equipment.

Founded in 1964, Khmelnitskiy National University (KhNU) is one of the leading universities of Podolia – a historical region in the western part of Ukraine. With academic staff of about 800 and a student body 11,500 the University includes 8 faculties and study programmes for 42 specialties. KhNU has established a strong cooperation with the JSC “Ukrtelecom”, Khmelnitskiy Aviation Factory and South Ukrainian Nuclear Station in the field of critical computing applications design. The Department of Systems Programming (SP) was established in 2004 from a few other departments. Critical domains: {power industry; traffic}.

With 11,000 students and 2,700 academic staff, National Aerospace University “KhAI” (KhAI) is one of the leading institutions of higher education in Ukraine for the training of specialists for the aircraft and aerospace industry in Ukraine and beyond. KhAI has branches in Mexico, Germany, Finland and China and cooperates with first rate national and foreign manufacturers of aircraft engineering: «Antonov», «Boeing», «Airbus» and participates in the international programs «Alpha» and «SeaLaunch». The Department of Computer Systems and Networks (CSN) carries out intensive research and methodical activities aimed at increasing the quality of engineering studies. Critical domains: {aerospace; nuclear power plants; medical and business-critical applications}.

Poltava National Technical University (PNTU) was established in August 18, 1930 as the institute for agricultural engineers. Now the PNTU is the state multi-profile university of Central Ukraine with more than 8,500 students and 450 teaching staff. The university operates with 55 specialized learning labs, which provide facilities for study programmes in 30 specialties. Research and development in safeware engineering related areas are carried out by the Department of Computer and Information Technologies and Systems. Critical domains: {buildings and infrastructures; oil and gas production and communications}.

The history of the Institute of mathematical machines and systems, National Academy of Sciences of Ukraine (IMMS NASU) started in 1960. Now it has become the leading scientific centre on situation modeling and management, decision-making modeling and other innovative IT technologies. It employs more than 200 academic and research staff, including 11 full doctors of science and 43 PhD. The key R&D area of the IMMS NASU is development and introduction of modern technologies, methods of mathematical modeling, automated systems for different problems and applications, etc. Critical domains: {critical management}.

Since 1955 the scientific technical specialised design bureau “Polysvit” (POLYSVIT) has carried out the development of hardware for aerospace objects – space shuttles, carrier rockets, aviation systems, etc. Now POLYSVIT is the leading Ukrainian enterprise for the design of specialised computer systems and devices for the aviation industry, in particular for AN-70, AN-140, AN-148 aircrafts. Further, POLYSVIT develops different systems for power industry, airports, etc. Critical domains: {aerospace; air traffic; power industry}.

“Radiy” Research Production Company (RADIY) was founded in 1954. It was the largest manufacturer of television studio equipment, mobile TV stations, and broadcast transmitters in the former USSR. Now RADIY is the leading designer and manufacturer of safety critical digital instrumentation and control systems for NPPs with reactors of VVER-440 and VVER-1000. In addition, RADIY produces computer based fire-fighting systems, systems for power industry, etc. State Committee of nuclear regulations of Ukraine, State Company “EnergoAtom”, State research centre of nuclear safety of Ukraine, Institute of nuclear research of National Academy of Sciences are among the partner institutions of RADIY. Critical domains: {nuclear power plants; power industry}.

The Ministry of Education and Science of Ukraine (MINISTRY) is the central body of the government executive power performing management in the area of education.

4. Project Objectives, Structure and Activities

4.1 Objectives

The following specific objectives have been defined for the project:
1. To develop MSc programme for the specialty "Safeware Engineering" which includes 5 modules MC1–MC5;
2. To develop PhD programme for the specialty "Safeware Engineering" which includes 2 modules PC1–PC2;
3. To develop in-service training programme (TP) with 3 modules TM1 – TM3;
4. To introduce the scheme for student mobilities between European stakeholders;
5. To establish the national network of centres for training and consultancy services in the area of safeware engineering.
6. To arrange the international conference "Innovations and Growths in SafeWare Engineering".

4.2 Structure of Modules

Target master modules have to be defined in terms of the following structure:
MC1 Safeware engineering foundations (Foundations of system safety; Safeware analysis program; Safeware design program; Safeware verification program);
MC2 High availability systems and technologies (Foundations of high availability systems; Architecture of high availability computer systems; Assessment of high availability of computer-based systems and networks; High availability systems management);
MC3 Co-design of safety-critical embedded systems (Component-based approach to safety-critical embedded systems development; Software-based safety-critical embedded systems development; FPGA-based safety-critical embedded systems development; Technologies of safety-critical embedded systems co-design);
MC4 Service-oriented business-critical systems and technologies (Service-oriented architecture (SOA) and architecting; Web-measurement for dependable SOA-based systems; Methods and technologies of web-composing for business-critical systems; Tools for SOA-based systems development and re-engineering);
MC5 Distributed critical systems and infrastructures (Foundations of "system of systems" engineering; Modeling and development of critical IT-infrastructures; Survivability of computer networks and IT-infrastructures; Evolvable systems).

Structure of PhD modules:
PC1 Formal methods-based technologies for safeware (Analysis of advanced formal methods for safeware engineering; Formal methods-oriented technologies of development; Formal methods-oriented quality assurance technologies; Integrated application of formal methods in critical systems);
PC2 Scalable diversity-based technologies for safety-critical applications (Requirements to application of diversity in safety-critical systems; Project decisions for multi-version systems; Technologies of diversity-based safety-critical systems development; Technologies of multi-version systems assessment and verification).

Structure of in-service training modules:
TM1. Safety-case-oriented systems requirement analysis (Foundations of safety-case methodology; International standards on safety critical systems; Functional and non-functional requirements; Process profiling of standards; Techniques of safety-case-oriented requirement preparation);
TM2. Safety-case-oriented system measurement and data analysis (Measurement and normalization of initial data; Process profiling of metrics; Assessment procedures and techniques);
TM3. Safety-case tools and innovative technologies of application (Comparative tools analysis; Techniques of tools selection and adaptation; Development and application of tools; Documentation processes).

These MSc courses will establish the Master specialty “Safeware Egnineering” to be taught at the target departments of Ukrainian universities starting from September 2012. The target courses will consist of 3-4 modules, their content will reflect the modern methods, techniques and tools used by the different aspects of safeware engineering for critical domains (CDs). Each module will have an equal structure developed in line with practice at EU partner universities and industry (lectures, practical studies, tasks for presentations and projects, test questionnaires etc.). The developed MSc courses will start from September 2011; PhD courses will start from January 2012 at partner universities. The developed training modules will be introduced from March 2012. All developed courses will have ECTS-compatible structure. The Reference team will agree on introduction of the mechanism of using the ECTS grading scale together with the existing one. It is not possible completely to replace the existing grading scale (“excellent”, “good”, “satisfactory”, “non-satisfactory”) because of the existing national regulations but the team will force this initiative to use the ECTS scale for the developed curriculum.

4.3 Project Management Activities

The project management team has defined the target group of the project beneficiaries.
a) KhNU: Department of Applied Mechanics and Resilience and Reliability of Machines (appr. 50 persons in the 2011/12 ac. year), Department of System Programming (appr. 80 persons in the 2011/12 academic year);
b) SebNTU: Department of Cybernetics and Computing (appr. 75 persons in the 2011/12 ac.year), Departments of Navigation and Shipping Safety, Power Plant of Sea Installations and Ships (appr. 50 persons in the 2011/12 ac. year);
c) ONPU: Department of Intellectual Computer Systems and Networks (appr. 90 persons in the 2011/12 ac. year), Departments of Nuclear Power Plants, Transport and Robots Equipment (appr. 60 persons in the 2011/12 ac. year);
d) KhAI: Department of Computer Systems and Networks (appr. 120 persons in the 2011/12 ac. year) and Department of Expertise Technologies and Safety (appr. 60 persons in the 2011/12 ac. year);
e) PNTU: Department of Computer and Information Technologies and Systems (appr. 60 persons in the 2011/12 ac. year) and Department of Oil and Gas Production (appr. 100 persons in the 2011/12 ac. year).

PhD students selected on a competitive basis will experience accelerated academic development in their research, writing and pedagogical skills while working within the academic teams to prepare new curriculum content, and will thereby contribute a dynamic layer to the teaching staff within the Ukrainian partner universities.

The developers teams of academic staff of involved institutions (universities and partners) will be trained in the relevant theoretical, analytical and research skills needed to design and introduce the above courses MC1-MC5, PC1-PC2 and TM1-TM3 as well to Ukrainian MSc and PhD students. The teaching staff will produce teaching and learning materials for each of the 7 targeted modules and 3 in-service modules (textbooks, readers, student workbooks, methodological guides, etc. in printed, CD and on-line versions for 5 MSc and 2 PhD modules and 3 training modules. The teaching staff will also upgrade their working knowledge of English.

The project management team has identified the main risk factor to be taken into consideration during the project lifecycle. Possible changes in the Ministry and State Accreditation Committee could have a negative impact on the project implementation. To avoid these problems all project activities will be performed with the involvement of a number of specialists from the Ministry and Committee to ensure continuous support of the performed activities.

5. Conclusions

To date the development of the Masters modules has been completed and the process of their discussion within the consortium universities is under way. Project implementation will ensure sustainable and comprehensive staff provision in the domain of safety IT-engineering for Ukrainian enterprises and institutions. In particular the following aspects will be affected:

1. Developed MSc programme on safeware engineering will be accredited and introduced into the learning programmes of 5 Ukrainian universities by August 2012;
2. Developed PhD programme for this specialty will be approved and introduced into the learning programmes of 5 Ukrainian universities by August 2012;
3. Developed in-service training programme will be implemented by trained staff of NNC offices in Ukrainian universities by January 2013.
4. General and special target groups of MSc and PhD students, lecturers and course developers of all Ukrainian universities will be trained with updated curricula and improve their skills in English during short-term study visits to European partners by August 2012.

The project will be finalized with the Conference “Innovations and Growths in Safeware Engineering” to be held in Ukraine at October 2012. The conference will summarize and disseminate results of the project and starts discussions concerning the new role and responsibilities of the modern studies in the area of safeware engineering.

6. Acknowledgements

The coordinators express their thanks to the EU members from different universities for their interest in the project and for their continued assistance in the various activities.

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Global Societal Responsibility – more than just sustainability

Bland Tomkinson
University of Manchester, Manchester, UK
bland.tomkinson@manchester.ac.uk

Abstract

The Royal Academy of Engineering sponsored project in Manchester to foster education in sustainability through inter-disciplinary problem-based approaches is already well documented. However, this was just one outworking of an original idea about global societal responsibility and the purpose of higher education. In 2002 Charles Engel posed this as the 'Ultimate Challenge'. That project resulted in a thoroughly evaluated interdisciplinary course unit that has spread beyond engineering and science and which is now available to students across the university, although currently most are still drawn from engineering and physical sciences. The idea is that 'wicked' problems are challenges to be faced by engineers, together with other professionals, in the context of a range of global issues, not just sustainability.

A further development in 2010, in pilot form, was for a course unit at Masters level looking at issues of Humanitarian Aid. The unit forms an optional part of a programme in the Management of Projects. This aptly underscores the nature of global societal responsibility in that, not only is the same problem-based, group work approach being used, but also one of the scenarios was held in common. This reflects the spectrum from disaster relief through development to sustainable development. In this instance all of the participants have been from overseas and this has added an extra intercultural and international dimension.

Taken together, the two pilot courses represent an approach to the broader concepts of societal responsibility that are incumbent upon today's engineers. More than that, the evidence suggests that not only do the students like this approach to learning but also that they have strengthened many of their transferable skills and competencies.

1. Introduction

The concept of global societal responsibility is something of a mouthful to say and possibly equally awkward to grasp. However, the idea that engineers should have a greater relationship with societal and environmental issues is one that has had increasing acceptance. In 2005, both the National Academy of Engineering in the US[1] and the Engineering Council in the UK[2] produced statements of professional values that explicitly incorporated the need for sustainable development and ethics. Moreover these august bodies pointed to the need for skills development within the engineering curriculum and not just engineering knowledge.

In 2002, Charles Engel had introduced the concept of interdisciplinarity for global societal responsibility in a keynote address to a symposium held jointly by the then UMIST and Victoria University of Manchester. Some of these ideas were subsequently developed into a conference paper[3]. A position paper, by Fortunato Christobal, Charles Engel and Jamsheer Talati[4], issued in 2009 looks at the global challenges facing all the professions, though primarily written from the standpoint of the medical and health professions. The authors set out a number of changes, not only local but dependent on global developments, that are likely to influence all professionals worldwide. These include:

- The continuing economic burden of having to finance large national debts.

- Growth in populations living at or below subsistence level.
- Unregulated use of technology.
- Reduction of biodiversity, desertification and pollution.
- Continuing population growth.

In order to tackle these issues, and the changes need to ameliorate them, the authors suggest that the professions need to take responsibility for:

- The underpinning research, as well as mitigating interventions, which are primarily international, interdependent and long-term.
- Provision of expert, long-term, non-partisan support to governments involving the whole spectrum of professions including agriculture, architecture, behavioural sciences, engineering, geography, health, law, sociology and veterinary sciences.
- Contributing collectively, from their growing expertise, towards the national and international exploration of the causes and consequences of the world's major problems.
- Extending traditional responsibilities to include outward-looking, proactive, interprofessional and intersectoral collaboration.

Looking towards the educational initiatives required to move such ideas forward, Christobal and his colleagues suggest: "Could universities justify an 'ivory tower' image by isolating themselves from the stark realities that face our planet? Noblesse oblige – let privilege be matched by responsibility." The position paper further suggests that "the universities of the 21st century should accept the responsibility of ensuring that their graduates will be able to adapt to change and participate in the management of change – not only within their own profession, but also on behalf of society at large. The linking of societal responsibility with participation in the management of change sets the expectation that universities and, thus, their graduates will accept supra-professional and intersectoral collaboration… This is the Ultimate Challenge to universities."

These are bold statements and represent a good premiss from which to re-examine engineering education. In a broader look at the drivers for change in the engineering curriculum, the author[5] suggests that "[an] ideal revision should, therefore, be on the basis of a *research-inspired, learner-centred curriculum*, that includes professional studies to add breadth, enhance student employability and improve student motivation and retention. This implies significant research-oriented learning, although other more passive or content-rich learning may be appropriate to a more limited degree – for example staff briefly sharing their research ideas with new students. The curricula might include some online delivery but it is important that each thread of the curriculum be agreed before seeking the appropriate means of delivery. In the initial stages, at least, learning in groups should become a key feature."

Dietrich Queis[6] looks at sustainable development as an inter-cultural issue that '…requires that we promote a basic attitude that involves curiosity and interest in the experiences and affairs of other people from other regions of the world and the desire to learn from others.' This demands a new pattern of teaching and a particular kind of educational practice in higher education that features:

- Active learning, interdisciplinary thinking and problem solving;
- The teacher as learning-enabler rather than knowledge-giver: educators act as models and learners;
- Learning takes place in relation to real-life situations; a focus on practical issues and actual experiences.

Together these ideas and initiatives can be seen as pushing forward a number of agenda in engineering education, but how do they come together in global societal responsibility and where does sustainability fit in? The Royal Academy of Engineering sponsored project in Manchester is already well documented [eg 7,8] but this was only the beginning.

2. The projects

2.1 Sustainable development

The first of the projects to embed an interdisciplinary, learner-centred, groupwork-based approach was based on the field of sustainable development, using a broad sense of that term. This arose because the Royal Academy of Engineering had a visiting professorship scheme in Engineering Design for Sustainable Development. The Academy was prepared to take broad, but courageous, perspective on this and funded a project that appointed a retired professor of medical education to the Visiting Professorship, who used some of his funding to pay for the support of a part-time assistant. The initial course unit took final year undergraduate students from science and engineering schools in the University of Manchester, but this has since developed to take a wider spectrum of students, but still mainly from science and engineering schools. A course unit is now also offered at Masters level.

From the start the intention was to look beyond the boundaries of Engineering, to develop skills as well as knowledge – particularly skills to participate in the management of change – and to steer away from the previous narrow approaches to sustainability education.

This project has been reported in a number of places and was a finalist in the Education category of the 2008 UK Green Gowns Award. A full report on the project was presented to the Royal Academy of Engineering, together with an Appendix detailing the stages of developing the course unit so that others might follow the same course of action. One aspect was that material used for 'scenarios' to present the challenges to the students should be current as well as relevant. This means that it has to be regularly updated and that it is not readily transferred from one teaching situation to another, rather that the process can readily be replicated rather than the actual case studies.

Each scenario features a messy or 'wicked' problem and the intention is that the degree of complexity increase through the unit in order to facilitate cumulative learning. Horst Rittel and Melvin Webber[9] define *wicked problems* as ones which:

- Have no definitive formulation;
- Have no clear end, no 'stopping rule';
- Have an answer that is 'good or bad' rather than 'right or wrong';
- Have no immediate or ultimate test of their resolution;
- Have consequences to every solution - there is no possibility of learning by 'trial and error';
- Do not have a well-described set of potential solutions;
- Are essentially unique;
- May be a symptom of another problem;
- Have causes with no unique explanation;
- Bring expectations that their 'owners' will find the 'right' answer.

Not all of these are needed for a problem to be *wicked* but wicked problems will display many of these features. Problem scenarios are sought from a wide range of staff within and outside the university and may be drawn from their recent research experience. The scenarios are then rewritten by the course team to ensure that they fit in with the developmental approach being taken to student learning and they may be disguised to ensure that students do not attempt to look up the 'right' answer.

2.2 Humanitarian aid

A second opportunity to involve engineering students in issues of global societal responsibility came with a proposal for a Masters-level course unit, following the ideas tested in the sustainable development course unit, in humanitarian aid. This proposal was initially funded by the then Centre of Excellence in Enquiry-Based Learning and the unit was formulated for the Masters course in Management of Projects in the School of Mechanical, Aerospace and Civil Engineering. Although based in an engineering school this course takes students from a wide range of backgrounds – most of them come from overseas and normally over half of the students have an engineering background, others coming from business management studies and from other science and built environment backgrounds.

The same basic procedure was used with this course unit as had been undertaken with the sustainable development units and, indeed one scenario – concerning a strategy for post-disaster transitional shelter – was carried across to the new unit. In the first year of operation the scenarios covered in the first year were:

- Transitional post-earthquake shelter in Kashmir.
- Disposal of ordnance in eastern Angola.
- Women's' health in northern Ghana – including aspects of ethics as well as risk analysis and programme planning.
- Briefing on inconsistencies in responses to earthquakes in Haiti and Chile.

In the second year a shorter (one week) introductory scenario was posed, largely to look at issues of information literacy and the other scenarios were:

- Food aid to East Africa involving GM maize.
- Post-Tsunami reconstruction in Indonesia.
- Disposal of ordnance in eastern Angola (a slightly expanded version of previous year).
- Strategic planning for future Haiti relief and reconstruction.

Assessment of the course unit is through group assignments and individual reflective reports.

The project has been monitored in a number of ways, including the use of nominal groups[10] (see below). Student comments at the end of the first pilot year included:

- 'The Humanitarian Aid module was amongst the best course experiences in the MSc Management of Project course … and I predict that it will certainly be extremely beneficial for my career as Project Manager'
- 'This module has helped me to overcome fears that I was facing in my life. It helped me understand how I worked with people from other countries and cultures.'
- 'Looking back over the whole course unit, I have updated myself with tremendous knowledge, achieved a better way of working, sharpened my possessed skills and learnt several new ones. It is a truly worthwhile experience and these skills definitely will help me in tackling any task in my future. I learnt to look at things from different angles. I developed an out-of -box thought process.'
- 'Some of the skills which I had definitely improved in are in research, analytical, communication, attention to details and team-working. In considering information from different sources, I have learnt to view it more critically rather than accept it as it is presented. This is true for newspaper or journal papers, which are often considered to be reliable sources.'
- 'Although there are no examinations at the end of the course, I feel that this course has been extremely demanding… However, not only that I have never regretted once in choosing this course, I have enjoyed every minute of it.'

2.3 Bringing the threads together

During the period in which the pilot Humanitarian Aid unit was being developed, a project proposal was put forward, and accepted by the National Teaching Fellowship Scheme, that seeks to extend the concepts further. The project, which is led by the University of Keele and also includes the University of Manchester and the University of Staffordshire, seeks to employ the concepts, of using problem-based learning methods for education for sustainable development, across a wider student audience. The main focus of this particular project is the use of technology to support larger numbers of students. The project is still in its infancy, indeed it has yet to be fully initiated at the University of Staffordshire, but the trial course unit at Manchester is that in Managing Humanitarian Aid Projects, rather than one of the sustainability units. This has yielded extra funds to support the continuation of the project but underlines the contiguity of issues of sustainability, disaster relief and humanitarian aid.

The questions about the extent to which technology can support this type of approach is dealt with elsewhere[11] but the course unit has been subject to both nominal group processes and also student questionnaire. The questionnaire used was largely common to that being used at Keele and the results of both will be processed together. The mid-semester nominal group process had a particular focus on the questions of technology and is examined elsewhere, but the end of semester process covered not just the student groups but also the group of postgraduate facilitators that had supported the unit. The nature of the groups is perhaps reflected in the attributes that came to the top – all those participating were from overseas. Communication skills thus featured prominently in all groups and multicultural working was also picked up both by students and facilitators. All students mentioned some transferable skills but for some the research skills had particular relevance. The subject matter also featured with 'Third-world issues' being specifically mentioned. These results are in line with the end of semester comments from the previous year. More negative observations centred around this approach to learning being more arduous than conventional methods and a concern about assessment that belies the approach taken. Facilitators also felt that they had learned much, as much about themselves as about education or humanitarian aid.

One of the facilitators observed that the Masters students took longer to settle in to working in groups and the general ethos of problem-based learning than was common amongst final-year undergraduates. All of the former, but only half of the latter, were overseas students and the undergraduates had a longer exposure to British ideas and to group working. This suggests that problem-based learning needs to be extended to allow greater time for development.

3. Conclusions

In the context of global societal responsibility these course units have developed sensibilities as well as skills and they have equipped engineers and others to better tackle a wide range of problems in conjunction with other professionals. For many of the post-doctoral and post-graduate facilitators this has provided not just a learning opportunity but also a career boost.

The pilot inter-disciplinary course units in sustainable development and humanitarian aid have demonstrated that a problem-based approach can work in fostering in students the skills to share and tackle multi-faceted problems across disciplines and cultures. Sustainable development is but one aspect of the range of intractable global issues and disaster relief is perhaps at another end of the spectrum although they do considerably overlap.

The learner-centred, problem-based learning environment described here is ideal for enabling students to tackle a wide range of wicked problems, occurring globally, in an interprofessional context. These are not just environmental or ecological, or even issues of sustainable development, but real problems that professionals must learn to tackle together.

Acknowledgements

I would like to thank Professor Charles Engel for providing the inspiration for this paper.

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Appendix: Humanitarian Aid Nominal Group results 2011

Mid-semester

Group 1		Group 2	Group 3	
Positives				
+ teamwork learning	∞	+ interactive effective communication	+ enhancement of generic skills	∞
+ handling conflicts	∞	+ taking up responsibility	+ different cultures	∞
+ no exam	7	+ understanding cultural diversity	+ real-time case study	5
+ dynamic nature	6	+ different way of learning	+ encourage debate skills	5
+ commitment to work	6	+ improve information searching skill	+ team development theory	5
+ how to communicate	5	+ self-adapting change skill	+ capability of communication	3
+ handling challenges	4	+ improving team skill	+ improve logical thinking	1
+ time management skills	4	+ individual skills eg planning, organising		
+ improving searching skills	4	+ people management skill		
+ self-criticism	4			
+ learning more	4			
+ critical thinking	3			
+ how to read papers	1			
Negatives				
- unclear requirements	∞	- time consuming	- unclear timetable and assessment	6
- is it practical?	7	- Blackboard	- Blackboard dysfunctionality	6
- time consuming	6	- lack of constant feedback	- ambiguity of feedback	5
- wiki not user friendly	6	- difficult to manage a group	- time consuming	4
- boring classes	6	- not gain specific knowledge	- group size too big	4
- teams gathered coincidentally	5	- difficult to combine opinions	- no interaction with other groups	3
- risk of losing commitment	5		- lack of basic methods	1
- lack of time	4			
- Not interesting topics	3			
- Lots of conflicts	3			
- internal usage	3			
- prejudiced topics	1			

In each cell the attributes are listed in priority order. The numbers given adjacent to the attributes suggested give the numbers in each group who voted for that attribute being included with ∞ signifying that the suggestion had the support of the whole group. The process was conducted without external facilitation and this meant that some groups did not always record the total number of votes cast.

For the mid-semester exercise the students were asked to focus particularly on the online aspects; the previous exercise had been undertaken entirely electronically (ostensibly online but some groups used less formal means of communication – eg mobile 'phones)

End semester

Group 1		Group 2	Group 3
Positives			
+ Self-criticism	∞	+ Increase communication skills	+ Improve language skills
+ Time management	6	+ Multicultural co-operation	+ Improve working skills
+ Co-operation	6	+ No exams	+ New and interesting subject
+ Critical thinking	6	+ Team working	+ Improve personal responsibility
+ Teamwork	5	+ Conflict management	+ Provide additional facilitation
+ No exam	5	+ Research skills	
+ Information search	5	+ Self-criticism/improvement	
+ Broader view of information	4	+ Understanding complexity	
+ Self-assessment	4		
+ Third World issues	3		
+ Effective communication	2		
+ Conducting meetings	2		
Negatives			
- Too much talk	∞	- Time consuming	- Too many exercises
- Tight deadlines	6	- Culture differences	- Lack of consistency
- Useful or not?	6	- Lot of coursework	- Repeating work
- Ill-defined task	4	- Wiki problems	- Ambiguity of assessment
- Time consuming	4	- Assessment split	- Different format of reports.
- Boring	3		
- Conflict	2		

Facilitators

Positives		**Negatives**	
+ Communication within team	∞	- Material appears disorganized	∞
+ Support from course leaders	∞	- Unsure how much to intervene	∞
+ Transferable skills learned	∞	- Guilt about facilitation quality	2
+ Multicultural mix	∞	- Lack of subject knowledge	1
+ Opportunity for reflective practice	2	- BlackBoard 9 frustrating	1
+ Opportunity to try PBL	2	- Frustrated with students' immaturity	1
+ Students bonding	2	- Ground rules need from start	1
+ Students contributing	1		

Online PBL: a route to sustainability education?

Bland Tomkinson, Ian Hutt
University of Manchester, Manchester, UK,
bland.tomkinson@manchester.ac.uk
ian.hutt@manchester.ac.uk

Abstract

The Royal Academy of Engineering sponsored project at Manchester; to foster education in sustainability through inter-disciplinary problem-based approaches, has since been extended to other groups and to a broader array of issues. One of the limiting factors is the ease with which this approach can be taken in the case of large numbers of students and a commensurate requirement for large numbers of facilitators. The University of Keele, together with partners from the universities of Manchester and Staffordshire, was awarded National Teaching Fellowship Scheme funding to explore further the use of blended or online approaches, in order to overcome these limitations.

In the case of the University of Manchester, the developments are being applied to a Masters-level course unit in Managing Humanitarian Aid Projects. This unit proceeds on the basis of five scenarios that students try to resolve in small groups and in the first pilot year one of these scenarios is being delivered on-line. The pilot unit already has a certain amount of support using the BlackBoard VLE but this scenario is supposed to rely entirely on online working. At the time of writing the evaluation of the pilot has not been completed but an online questionnaire has been devised to monitor students' reactions to the online working and to ascertain whether they did in fact work entirely online or whether they chose to meet informally face-to-face. Difficulties encountered were both organizational (mostly relating to enrolment) and technical (this was a new version of BlackBoard and had a few teething troubles). The results of this pilot will be fed in to later stages including the possibility of distance learning modules.

1. Introduction

An inter-disciplinary, problem-based approach to education for sustainable development has been implemented in Manchester for a number of years and is already well documented [eg 1,2]. Initially this was across science and engineering but latterly more broadly across the university. However, this has been but one course unit in one university and the pioneers of the idea have sought to make the approach more widespread. One of the limitations, however, is the difficulty of using a problem-based approach with large numbers of students – each group of eight or nine students requires a post-doctoral or post-graduate facilitator. In order to try to resolve some of these issues, in 2009 Professor Pat Bailey of the University of Keele obtained a National Teaching Fellowship Scheme (NTFS) award to look at issues of implementing the ideas, through blended learning, at three universities. This paper looks at the developments in the University of Manchester. In this instance three course units are involved: at undergraduate and Masters level in Sustainable Development and at Masters level in Humanitarian Aid. The trial is initially confined to introducing blended learning to the Managing Humanitarian Aid Projects unit of the MSc in Project Management in the School of Mechanical, Aerospace and Civil Engineering.

The case for using problem-based learning as a basis stems from a number of origins. In a UNESCO report[3], Arjen Wals suggests that the 'nature of [education for sustainable development] demands new perspectives on matters like curriculum, teaching and learning. ESD and SD tend to focus on connections, feedback loops, relationships and interaction. Yet dominant educational structures are based on fragmentation rather than connections and synergy'. Sulaiman Yamin and Alias Masek[4] suggest that '… PBL is seen potential[ly] as an effective learning approach to produce … graduates, who are technically competent, as well as aware on the issues [of] sustainable development' and a report[5] from Rosemary Tomkinson and colleagues, on a Delphi study, suggested that student-centred approaches were most relevant to embedding education for sustainable development.

The use of technology to support large classes has been widely explored but its application to student-centred, group-based learning is less widely recognised. For example, Hao-Chang Lo[6] has looked at the implications of using publicly-available communications technology for a PBL-based medical course and Xun Ge and colleagues[7] have studied the use of technology to scaffold the PBL learning processes. Rosman Ahmad[8] explored online methods for a programme related to the one under study but this fell short of participative groupwork. A much fuller review of the available literature was undertaken in the bid document itself.

1.1 The trial

The NTFS project is over a three-year period and a phased approach is being taken. The Managing Humanitarian Aid Projects course unit employs four major scenarios, with a minor one as an introduction to the approach. Each scenario is designed as what Horst Rittel and Melvin Webber describe as a wicked[9] problem, with no obvious answer. Each group of about eight students tackles each of the problem scenarios over a two-week period, producing a group report which may take several forms depending on the nature of the problem scenario. The unit seeks to develop specific transferable skills as well as to enhance knowledge and the methodology is in line with that described in more detail in an appendix to the report to the Royal Academy of Engineering[10].

For the purpose of this latter study, the second of the major problem scenarios was chosen to be delivered entirely online. This particular problem scenario was looking at reconstruction in the aftermath of a recent Indonesian tsunami. The initial scenario (see Appendix) was posted to the BlackBoard site on controlled release, so that it could not be previewed. As well as the description of the problem, links were posted to news sites with more background material. Over the next two weeks each group was expected to collaborate online to define the aspects to be tackled, to carry out the background research and to formulate a response in the form of both a written report and also a set of PowerPoint slides to accompany an oral presentation. The result was submitted through BlackBoard and formative feedback was also given electronically.

The course unit is already well-supported online. At the time of the trial the university was introducing BlackBoard 9 and it was decided that this course unit would be one of the pilot modules mounted on that learning environment, partly because it was expected that the University of Keele would also be using BlackBoard 9 for the project. In the event, this did not happen at Keele. The Managing Humanitarian Aid Projects course unit was running for its second year, having been funded by an internal development grant for the first year. The BlackBoard 8 system had incorporated some online discussion tools – which had not been used by students – as well as providing a repository for much of the course information and copies of supporting handouts. In BlackBoard 9 the students also had access to an individual journal tool – an individual reflective report is an essential part of the assessment for the unit – as well as a wiki space that could be used for drafting the group report. Further asynchronous communication tools were provided, including group and general discussion forums and a file-sharing area. Unfortunately, due to some technical problems with the new platform, the usual synchronous communication tool, Wimba Pronto (an application similar in function to Skype), was not available. Assessment is primarily in two forms: a group project report and an individual reflective report. Group reports have to be submitted electronically through Turnitin®, but only the final two scenarios count formatively, and the results are modified by a peer assessment exercise, which is currently paper-based. In this case the groups were also required to submit their report in the form of a group wiki in the first instance, which was later packaged up for Turnitin® submission. Reflective reports should be derived from the individual journals, though not all students have used the electronic tool for this purpose, and are also submitted through Turnitin®.

In addition to project management students, students undertaking a Masters programme in international development policy and management were also able to enroll on the unit; in the event only one student did so. Enrolment proved something of a challenge since Masters students are allowed a three-week period to decide on which elective units they will pursue, after which they are formally registered on the unit, and this means a considerable number of changes in the student body at the beginning of the unit. Whilst not wishing to unduly restrict student choice, in this instance students were not allowed to enroll on the unit after the second week.

A major issue in a pilot scheme of this nature is the nature of the instructional design. In this instance the blended learning approach is being applied to an existing course unit and therefore models the previous face-to-face approach. Other modules may be designed *ab initio* and therefore take a different approach. In other cases, such as that considered by Richard Kenny and colleagues[11], this will incorporate the facility of monitoring student discussions in order to assess the processes of the student rather than merely the outcomes.

1.2 Evaluation

The evaluation of the online part of the course was undertaken using both an online questionnaire and also a nominal group exercise[12]. Later, a second nominal group was conducted, covering the whole course unit and a short, paper-based, questionnaire was administered to the students also covering the whole course unit. The unit is also subject to a university-wide online student satisfaction questionnaire which is of dubious value in this context since it is constructed largely for a lecture-style format of teaching.

2. Results

2.1 Online questionnaire

The twenty-three students undertaking the unit were asked to complete an online questionnaire about their experience and fifteen students (65%) responded. The questionnaire comprised thirteen statements plus a free-text area for general comments. Students were asked to rate their level of agreement with each statement on a five-point Likert scale ranging from “Strongly Disagree” to “Strongly Agree”.

Figures 1 and 2 show the results for questions related to technical and training issues that might have prevented effective access to the online systems (highlighted bars show median values).

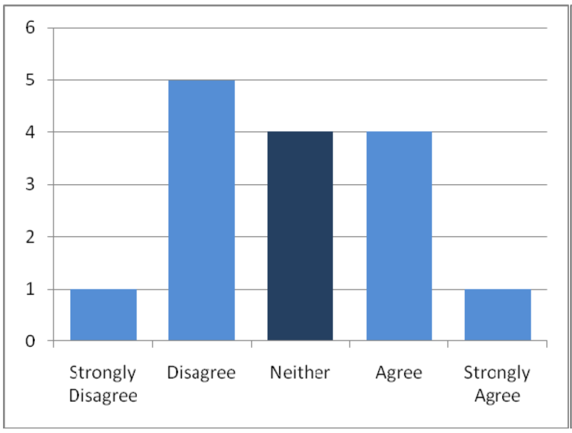

Figure 1: Q1. Technical problems prevented me from using Bb9 and the online tools effectively.

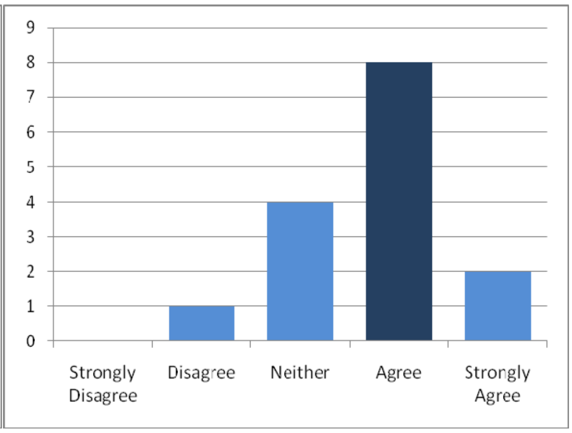

Figure 2: Q2. I received sufficient instruction to be able to use Bb9 and the online tools effectively.

reflects some initial technical issues that arose at the very outset of the trial, though it should be noted that the number of support requests dropped to zero after these problems were resolved and no further support requests were received after the first 3 days of the trial. Pre-trial instruction was a 30-minute walkthrough of the Blackboard 9 platform and tools and from the results of Q2, appears to have been sufficient (1 of 15 students disagreed).

The first area of interest in the trial was the presentation of online briefing material. In addition to task instructions, this included links to relevant websites and a BBC documentary provided through the Box of Broadcasts service. The results shown in figure 3 suggest that this was well received (only 1 of 15 students disagreed).

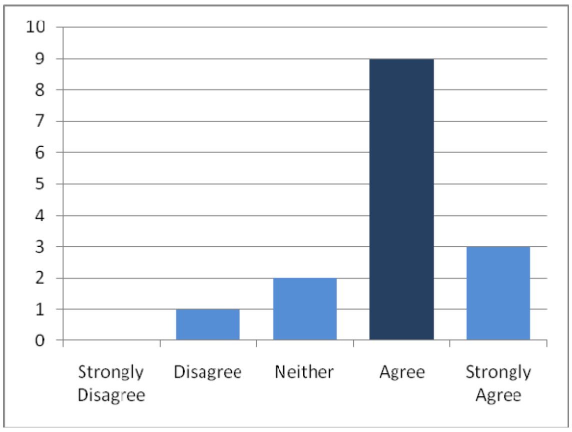

Figure 3: Q3. The websites and other online resources presented through Bb9 provided useful background to the scenario.

The next set of questions focussed on the groupwork experience. It appears that while the students generally felt that they were able to collaborate effectively as a group (figure 4 – 3 of 15 students disagree), they were less positive about their ability to engage with their group facilitator (figure 5). In at least one case the facilitator experienced technical difficulties in joining an online meeting and this may be reflected by the mixed responses shown in figure 5.

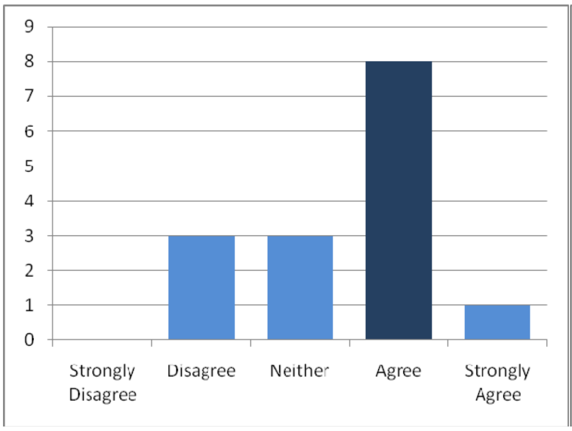

Figure 4: Q4. My group was able to collaborate effectively online.

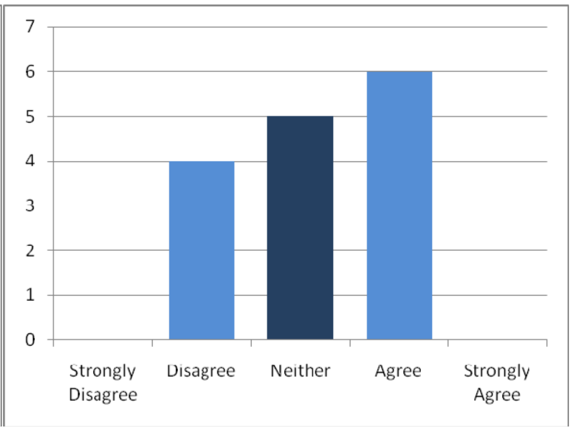

Figure 5: Q8. I found that my group was able to engage effectively with the facilitator online.

As might be expected, results regarding the use of the communication tools showed a definite distinction between asynchronous collaboration, for which several tools were provided, and synchronous collaboration, for which no specific tools were included. Figure 6 shows that the majority of students (11 of 15) found the asynchronous tools effective, while only 5 of 15 agreed that the provided tools were sufficient for synchronous meetings (figure 7).

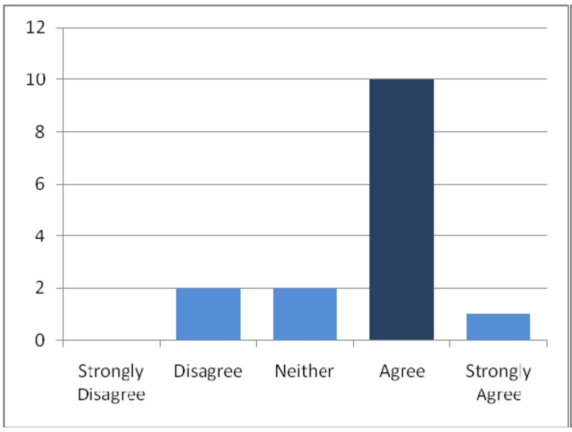

Figure 6: Q6. The discussion groups and similar tools enabled my group to communicate even when we were not all online.

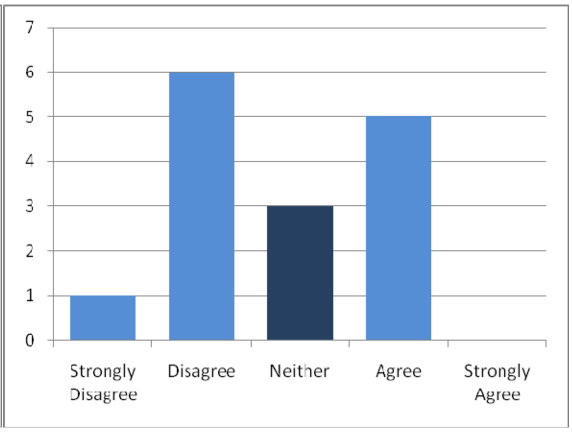

Figure 7: Q5. The online tools provided enabled my group to hold effective online meetings.

The lack of provision of any specific synchronous collaboration tools clearly drove the students to seek solutions outside of the platform provided to them, as illustrated in figure 8 where 14 of the 15 students stated that they used additional tools for their meetings.

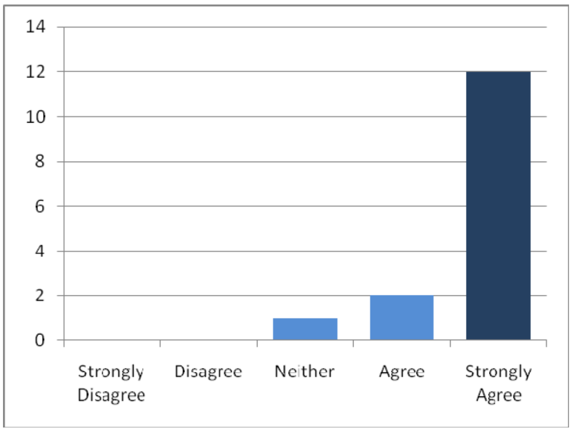

Figure 8: Q7. My group used additional online tools (e.g. Facebook) to collaborate online.

Observations of activity during and after the trial suggest that, while all student groups made extensive use of the discussion, file exchange and wiki tools within Blackboard 9 for sharing resources and providing progress updates, all online meetings tool place outside of Blackboard. Further investigation revealed that tools and services used were as follows (no of students who stated they used each tool shown in brackets):

Q14. If your group used any alternative tools for online collaboration beyond those provided within Bb9, please indicate which tools you used...

- Facebook (11)
- Skype (12)
- Email (12)

- Mobile phones (5)
- Google Docs (1)

The next set of questions focussed on the students' preferences and their feelings about undertaking the task online. So far, with the exception of the particular issues of facilitator engagement and synchronous collaboration, the results presented have been reasonably positive, but figures 9 and 10 suggest that the students still prefer face-to-face meetings.

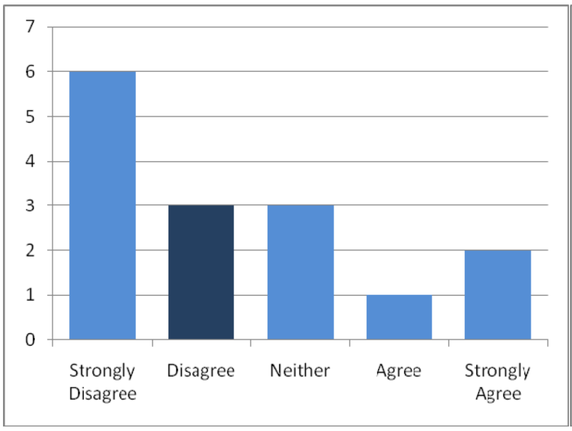

Figure 9: Q9. I prefer meeting online to meeting face-to-face.

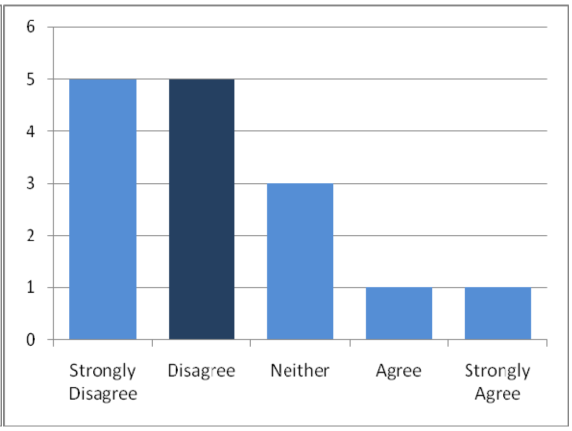

Figure 10: Q10. I contributed more to the online discussions than I would in a face-to-face meeting.

In a similar vein, students also rated the creativity of their online group problem solving lower than in their face-to-face meetings (10 of 15 agreed). This is shown in figure 11.

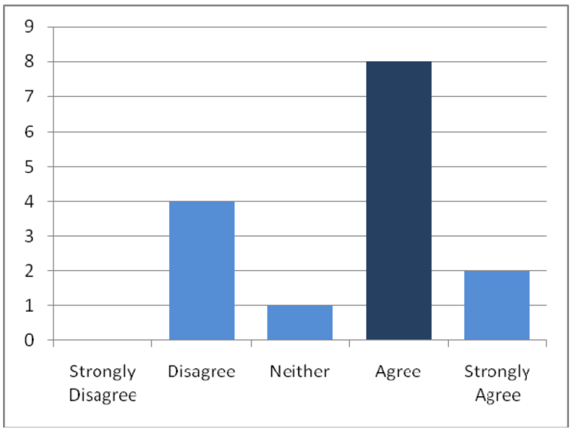

Figure 11: Q11. I feel that working online made our collaborations less creative.

This result is supported by some of the comments submitted in the general comments field – examples include:

Q15. Do you have any further comments you would like to add about your experiences of online group-working for Scenario 2?

- "I think It was a good experience, but a hard one."

- “I found it hard to fulfil our commitment when collaborating online.”
- “Communicating through computer or other tools is time consuming.”

There is a general theme that while they found it possible to work effectively as a group online, students also found it more difficult. It is possible that the students were having to dedicate more time and effort to the use of the online system, which had an impact on their creativity and productivity. An assessment of the quality of the submitted solutions by the tutors may help to clarify whether this perceived reduction in creativity is borne out by the actual submitted work.
The final questions in the survey related to the group wiki that the students were asked to produce as their final report. Figures 12 and 13 show these results.

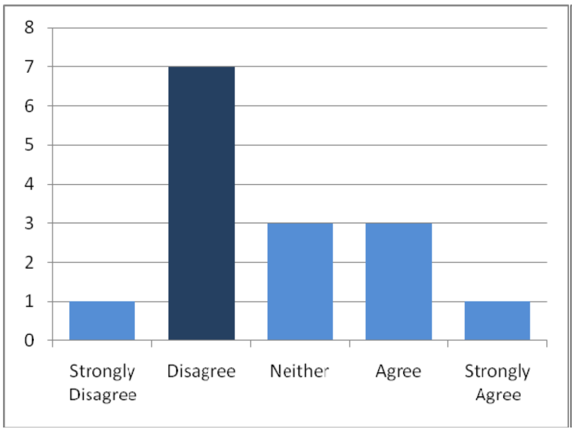

Figure 12: Q12. I found the wiki to be an easy to use and intuitive way to create a group report.

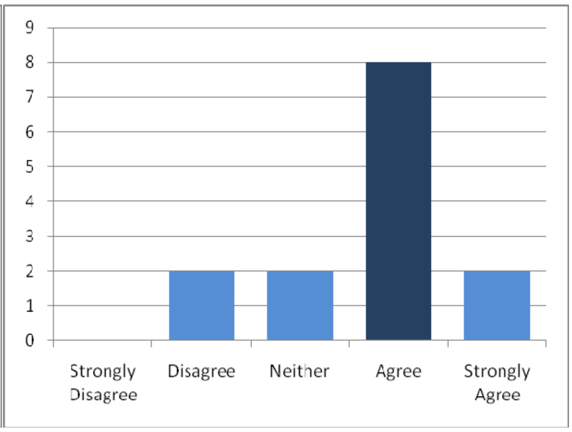

Figure 13: Q13. Everyone in my group contributed to the group wiki.

In general the wiki appears to have been an effective way to get all of the group members to contribute to the final report (figure 13), but the approach was not a popular one with the students (figure 12).

As with previous result related to perceived reductions in creativity, it is not yet possible to determine whether the difficulties in using the wiki are due to a lack of familiarity with the system or to an inherent lack of suitability of the tool to this task. Further investigation will be required to untangle this issue.

2.2 Nominal group

A nominal group exercise was carried out shortly after the second exercise had been completed. Each group of students was asked to individually list the positives and negatives of online PBL, based on their recent experience, and then to set those in order. They were asked to record the number of votes cast for each attribute, setting as infinity any with complete agreement of the group; one group failed to complete this latter stage. The results are summarised in Table 1. It will be noted that many of the positives are associated with group-based experiential learning but many of the negatives are associated with the online environment.

3. Conclusions

This pilot project has demonstrated that a blended approach to PBL is feasible but that it meets with a certain resistance from students. Some of the issues raised by the students can be resolved with greater familiarity with the VLE in use – in this instance the students were using two different versions of the BlackBoard system according to the individual course unit. One point of discussion is the extent to which online learning should take place through a university VLE: in this instance a variety of other electronic approaches was taken outside the formal structure. For the course unit in the pilot study the assessment was outcomes-driven rather than process-driven which meant that it was not necessary for the academic staff to have access to all the discussions. However, there were problems in facilitators having access to provide relevant support; in one case where much of the debate was through Facebook the facilitator concerned was not joined into the group until a very late stage. It should be noted that facilitators did not receive any training in the use of the systems beyond that received by students. In future trials, the inclusion of a dedicated synchronous communication tool, in the form of Pronto, and further instruction for facilitators should help to alleviate these problems. Equally of concern is the difficulty of remote access where firewalls have been installed and this could become a very real problem if the unit is extended to become available to part-time students working largely online.

The overall NTFS project is looking at the application of online PBL in sustainable development education and it could be argued that this pilot is somewhat peripheral to that. However, the field of global societal responsibility has a spectrum of approaches where humanitarian aid and disaster relief can be seen to overlap with sustainable development; indeed one of the scenarios used in the first year of the course unit was identical to one used in the parallel unit in sustainable development and others cover similar areas.

Table 1 – Results of nominal group exercise

Group 1	Group 2	Group 3
Positives		
+ teamwork learning + handling conflicts + no exam + dynamic nature + commitment to work + how to communicate + handling challenges + time management skills + improving searching skills + self-criticism + learning more + critical thinking + how to read papers	+ interactive effective communication + taking up responsibility + understanding cultural diversity + different way of learning + improve information searching skill + self-adapting change skill + improving team skill + individual skills eg planning, organising + people management skill	+ enhancement of generic skills + different cultures + real-time case study + encourage debate skills + team development theory + capability of communication + improve logical thinking
Negatives		
- unclear requirements - is it practical? - time consuming - wiki not user friendly - boring classes - teams gathered coincidentally - risk of losing commitment - lack of time - Not interesting topics - Lots of conflicts - internal usage - prejudiced topics	- time consuming - Blackboard - lack of constant feedback - difficult to manage a group - not gain specific knowledge - difficult to combine opinions	- unclear timetable and assessment - Blackboard dysfunctionality - ambiguity of feedback - time consuming - group size too big - no interaction with other groups - lack of basic methods

4. Acknowledgements

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Appendix

Exercise 2 (Online)

You are a team of ‘facilitators’, working with international aid agency *Building for Humanity*, which encourages collaboration between architects, builders and designers and the humanitarian world.

Background
On 25th October 2010, eleven-year-old Amina was sitting in school. “When I noticed my pencil rattling on the desk I quickly ran outside,” recalls Amina. Some of her classmates were less fortunate and unable to save themselves. On the islands where the girl lives, schools suddenly ceased to exist or were seriously damaged. The earthquake triggered a tsunami that swamped coastal villages on the Mentawai Islands and swept away many of the buildings that the earthquake had left standing. With logistics provided by the military, much was done to save lives by the simple provision of tents and tarpaulins, but longer-term assistance is required to help the population rebuild their communities and infrastructure, whilst providing medium-term solid shelter (transitional accommodation).

Task
Immediately following this incident, as a multi-disciplinary team, your aim is to assess the situation on the ground and, with the help of the following:

- Local community groups
- Local police and security forces
- Army and other military personnel
- Aid agencies and charities – both at organisational level and in the field
- Non-governmental organisations (UN, UNHCR, ICRC, etc.)
- Designers
- Manufacturers
- Other organisations (including health organisations and food charities)

….to develop a strategy to provide suitable transitional accommodation (housing, schools, clinics, etc). It is vitally important that all issues of sustainability are taken into account, and a realistic balance is achieved between emerging technologies and the constructional methodologies traditional in the area. Take account of potential transport difficulties, severe shortages of skilled labour and building expertise, as well as the availability of potentially suitable building materials. It is worthy of note, at this point, that many of the surviving buildings were of locally traditional construction.

You are to analyse possible alternative approaches and propose an environmentally sound and sustainable **strategy** for the construction of buildings, listed above. Achieve a realistic and workable balance between international aid and local skills and manpower. Make a reasoned proposal for a technological strategy which, if employed, would facilitate the creation of sustainable and safe buildings, and act as the building blocks of a longer-term rebuilding of communities. Present your analysis and proposals both as an A4 report of up to 1000 words and a set of PowerPoint Presentation slides that could be delivered in approximately 20 minutes. These must be submitted through BlackBoard.

Note: This is not a physical design exercise. Do not attempt to design any buildings. Instead, design an appropriate and workable strategy based on best current knowledge. Any such strategy must be workable, sustainable, affordable in both the short and longer terms, and should propose an appropriate **project plan** for all potential participants (local and international).

Problems of Assessment

Bland Tomkinson, James Freeman
University of Manchester, Manchester, UK,
bland.tomkinson@manchester.ac.uk
jim.freeman@mbs.ac.uk

Abstract

Learning about resolving complex problems means that modes of assessment become less deterministic – real world problems rarely pop up in a form that can be readily solved by an equation or two. This often means the use of projects, portfolios and dissertations. Even simple mathematical problems can give rise to differences of opinion in marking but in the case of the less structured assessments – where answers may be 'better' or 'worse' rather than 'right' or 'wrong' – the assessment issues are much more stark. When classes are large and the number of assessors equally substantial there are issues of reliability.

In, for example sustainability education in its broadest sense, it is important to grasp the complex nature of the 'wicked' problems that this involves. This inevitably means coping with problems for which there is no defined answer. Part of this can involve learning to work collectively on an issue and the assessment concern then becomes one of marking group assignments and, possibly, the use of peer assessment. Part of it may also involve the use of individual portfolios or reflective logs and these pose a different type of concern. In many cases there can also be an individual project and the question of marking individual project reports or dissertations is a vexed one.

This paper looks at some of the issues around the reliability of assessment in such circumstances and uses a large sample, drawn from the marking of Masters dissertations in a related area, to examine issues of double marking. This study suggests a wide disparity between individual markers and that the practice of using a third marker, when the disparity in an individual case falls outside a given range, does not necessarily improve reliability.

1. Introduction

Keith Willey and Anne Gardner[1] suggest that '[in] an effort to achieve consistent grading between multiple markers, double-blind marking and/or re-marking a random selection of assessment tasks is often undertaken. However, with high student numbers and teaching loads these activities are fast becoming unrealistic.' As with Willey and Gradner, many of the issues surrounding marking of dissertations have been concerned with the undergraduate arena where difficulties of marking substantial numbers of project reports are considerable. However, there has been a tendency for postgraduate taught numbers to increase to much the same levels as undergraduate courses. At this level, issues raised include types of assessment peculiar to specific subjects – for example examination of practicum rather than of dissertations. Likewise, some of the more generic studies have focused on the need for detailed marking schemes to increase the accuracy of marking and the validity of various approaches rather than looking at the reliability demonstrated typically by blind double-marking. Raija Kuisma[2] suggests that '… both intertester and intratester reliability are questionable.' And goes on to suggest that '… despite very rigorous experiments and experienced markers the reliability is low… '. However, as with many other researchers, his concern is primarily with the marking of essays and other assignments throughout a course unit rather than a more substantial piece of work represented by a dissertation or thesis.

In this paper reliability is taken to mean the ability to reproduce the same mark for the same piece of work whereas validity looks at whether the assessment is appropriate to the learning. In terms of reliability, the marks of supervisor and second marker can be seen as estimates of the 'true' mark.

At a November 2010 Examinations Board, some disquiet was expressed by a small number of examiners about the effects that second and third marking were having on their perceptions of the relative merits of their candidates. In this particular university, there is at present a system in place that allows for marks to be averaged when they differ by less than 10 points but for third marking to take place when the difference is greater, or where the resulting average comes close to a grade boundary. The third marker has earlier marks available and this avoids the difficulties that can arise when a third marker marks outside the range of the other two. Although some difference in views on marking can be tolerated, the concerns expressed were that the effect of the second (and sometimes third) marker was to change the rank order of the candidates marked by the supervisor. One supervisor had two candidates awarded the same mark although he had failed one candidate and awarded the other a distinction! This prompted a study of the data from that year's results as well as a wider look at the issues involved.

Because of the subject matter and the sheer size of the cohort, candidates had been allowed to undertake empirical research, or 'desk studies', or to conduct thorough and critical literature reviews as a basis for their dissertations. Markers were given a detailed assessment sheet that attempted to ground the marks by reference to criteria rather than norms. This is shown at Table 3.

Sue Bloxham[3] suggests that four assumptions underpin a, largely unchallenged, view of the reliability of assessment "in the higher education community:

1. We can accurately and reliably give a mark to most students' work.
2. Even if individuals' marking may sometimes be inaccurate, internal moderation ensures fair and appropriate standards in marking.
3. Even if internal moderation does not reflect expected standards, external moderation ensures students are assessed against consistent standards across the UK University sector.
4. Students' final award (degree classification) reflects their achievement in a consistent way within and, to a certain extent, across universities."

She then goes on to demolish all of these 'false' premises.

Differences in mark can arise from a number of sources. In this instance the first marker is always the student's supervisor and the mark given may be coloured by the student's performance during the research for the dissertation. Typically this is more likely to be a 'halo' effect where supervisors give higher marks than the written work merits because they have been aware of the effort and thought processes, which they then read into the dissertation although not present. The opposite 'horns' effect can also be found where a dilatory student produces a dissertation of greater merit than the supervisor has been led to expect. John Archer and Barry McCarthy[4] suggest that the halo effect can also be produced by performance in other parts of a course and, even by other members of academic staff. Barry McKinstry5[6] and colleagues, looking at the marking of undergraduate project reports, suggest '… that the supervisors mark significantly higher than second markers, suggesting a leniency effect. This indicates that the supervisor's mark is influenced by having known and worked with the student.' They go on to suggest that this underlines the importance of clear criteria and also of training in using them. A second source of error can arise from a lack of subject familiarity. To some extent, a dissertation is expected to generate new knowledge but second markers may have only a very limited grasp of the subject area. Raija Kusima suggests that '… lecturers have different views and differing levels of knowledge and therefore their expectations of students' level of understanding vary and emphasis may be on different aspects of the written work' and Cathy Edwards[6] suggests that '… assessors are subject to overlapping but not co-terminous institutional and professional values from within the institutions and professions in which they work'. Markers new to the role may also have a lack of view of the standards to be applied; a paper by the authors[3] suggests that those marking on a course unit for the first time award significantly different scores to those given by more established assessors and goes on to suggest initial training to help overcome this effect. In the instance examined in this study a ‘buddy’ system was put in place to help ‘external’ assessors.

2. The Study

The student cohort numbered over three hundred, although some either did not proceed to the dissertation or had the marking suspended pending examination re-sits. A total of ninety-two assessors were employed on the marking process, some marking only two or three dissertations. In the initial analysis it was thought that there were ninety-three assessors but two of them proved to be the same individual with variations in the name used! Many of the second markers were from a different part of the school with little detailed knowledge of the subject matter of the dissertation.

Two approaches were taken to the data. First, a study was done of the differences in marks between pairs of markers – for this purpose the marks awarded by third markers were ignored. First and second markers were not paired and only infrequently did the same pair mark a second or third dissertation. For each marker an average difference was calculated. The markers were divided into four groups:

A. Individuals who had supervised dissertations and who had also been available for second and third marking. These are essentially core members of the team for this particular programme.
B. Individuals who had supervised dissertations and had also been available for second marking. These are, in some way, connected to the programme and are largely serving or recently retired members of the School.
C. Individuals who had supervised dissertations but were not considered for second marking. These are largely, if not entirely, external supervisors.
D. Individuals who had second marked dissertations but had not supervised. These are drawn from the full-time staff of the School but may have only limited knowledge of the dissertation topics. In this case academic staff from a ‘hard science’ background might find themselves marking dissertations on management or social issues.

The second approach was to subject the larger data tables to tests for correlation and analysis of variance.

3. Results

3.1 Pairwise comparison

Tables A1 and A2, in the appendix, summarise some of the results so far. These tables are derived from an analysis between pairs of markers: for each marker the average difference from his or her co-markers has been calculated. A negative difference indicates that this marker generally gives fewer marks than others, whereas a positive score indicates that this individual gives higher marks on average. The range is from one individual who, on average, awarded marks 22% lower than those awarded by others marking the same dissertations, to two individuals who awarded marks on average more than 14% higher. A test was carried out to see if the average difference was in any way correlated with the number of scripts marked. The correlation was found to be very low and, hence, not significant. However, it is noticeable that in the case of the top ten differences the average number of dissertations marked was only 3.

For Group A (see above) the weighted average difference was -0.61; for Group B +2.27; for group C +1.77 and; for Group D -1.98. These figures disguise considerable variation within the groups and only Group D shows any significant difference (at the 95% level) from the overall average.

As might be expected, Group A shows the greatest consistency, with a standard deviation of 4.2, but this still represents a range of average marking difference from -6.18 to +6.80. This group undertook the third marking of dissertations where there was a substantial gap between first and second markers and, in such cases, their mark was not averaged with the others. However these markers were given the results of previous rounds of marking and were required to produce a mark within that range.

An exercise was undertaken to reassign marks to 275 candidates, for whom there was full information, applying the average of the differences for individual markers to the average of the two marks and comparing this with the actual results awarded. The results of that exercise suggest that 38 individuals would go down a grade and 33 would go up a grade; moreover 16 individuals who had passed would instead have failed and 9 who failed would have passed. In this case the grades considered were: Fail; Pass; Merit; Distinction. However, in both instances there are a number of borderline cases such that probably only half of those numerically below the boundary would actually have failed and rather less than the 38 individuals would have gone down a grade. Of the 275 dissertations reviewed, 69 had gone to double marking and of these 33 differed in mark by one grade from the calculated score, ten producing a difference one grade higher than the calculated score and twenty-three one grade lower.

3.2 Variance and regression analyses

A regression of the actual mark awarded on the average of first and second marks, unsurprisingly, showed a near-perfect regression in terms of R-squared results.

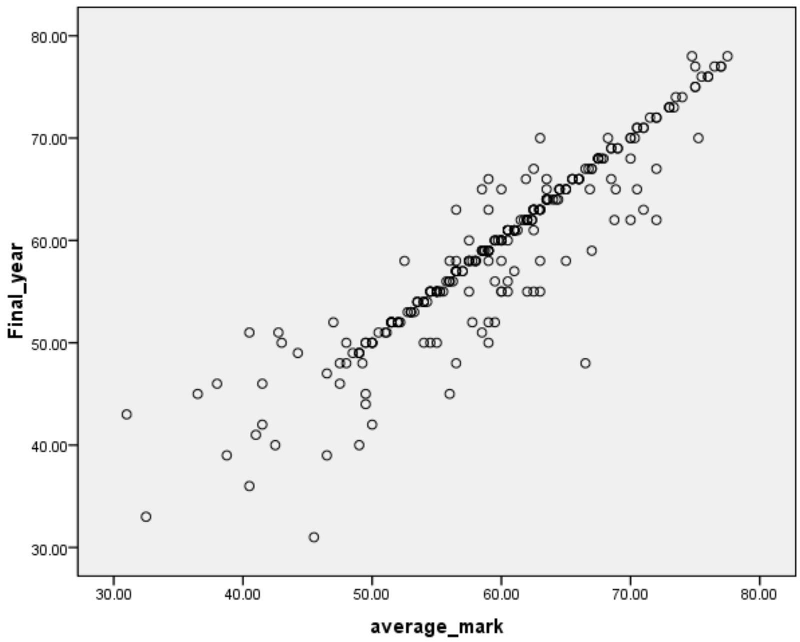

Figure 1: Plot of Actual final marks against average of first and second markers

Clearly, from this, some average marks are way out from the final year marks allotted. So something seems to be going on outside what is on the spreadsheet if these figures are valid. An analysis of variance (see Table 1) features 26 outliers (standardised residuals either < -2 or > +2). The expectation was that this analysis would give only 14 (ie 5% of 275) outliers. Details of the standardised residual values show that certain markers seem to proliferate e.g. 10, 28 and 38. These markers and to a lesser extent the others shown seem to be the most problematic in terms of discrepancies with the double marking. These assessors are part of the core team who undertake third marking and whose figures suggest that they are relatively ‘hard’ markers.

Table 1: Results of the analysis of variance model

ANOVA[c,d]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	973733.803	1	973733.803	86696.766	.000[a]
	Residual	3066.197	273	11.231		
	Total	976800.000[b]	274			

a. Predictors: average_mark

b. This total sum of squares is not corrected for the constant because the constant is zero for regression through the origin.

c. Dependent Variable: Final_year

d. Linear Regression through the Origin

Coefficients[a,b]

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics	
		B	Std. Error	Beta			Tolerance	VIF
1	average_mark	.992	.003	.998	294.443	.000	1.000	1.000

a. Dependent Variable: Final_year

b. Linear Regression through the Origin

Residuals Statistics[a,b]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	30.7524	76.8810	59.0236	8.38124	274
Residual	-17.96884	12.24761	.07860	3.35042	274
Std. Predicted Value	-3.373	2.131	.000	1.000	274
Std. Residual	-5.362	3.655	.023	1.000	274

a. Dependent Variable: Final_year

b. Linear Regression through the Origin

An analysis of variance of marking difference by marker type showed those in group D to be significantly different from the others but also contributing little to any overall result. Although not readily applicable, the analysis suggests a regression equation to produce a final mark of y = 6.03 + (0.911 x average of both markers) – (0.11 x difference in marks) + 0.352 x (group A mark) – (1.19 x group B mark) – (0.470 x group C mark). However, this still leaves twenty cases with a large standardized residual. Further analysis is necessary to resolve this.

4. Discussion

There is concern that steps should be taken to reduce the effect of potential marker error. As a result of the initial feedback on this study, the programme team is taking a number of steps to try to reduce the disparity is marks. First, each individual marker will be given advice as to where their marks lie, relative to others. Second, markers will be expected to undertake a larger marking load than three or four dissertations; third, and related to this, the team of markers will be reduced. Finally, permission will be sought to employ some of the 'external' supervisors as part of the second marking team, reducing or eliminating the use of markers from beyond the subject area. The success, or otherwise, of these moves will be monitored and any necessary changes introduced. Initially it had been hoped that a more robust statistical method could be found to reach a final mark, other than using third markers, but the sheer number of markers involved has caused considerable problems of data manipulation, which cannot readily lead to a numerical approach, but which might be resolved in future years. Manipulating the results using the average differences in marks between markers would materially affect the results of about a quarter of the students and there is a judgement to be made as to whether this represents a 'truer' result. Moreover, this approach would not necessarily overcome any individual biases in the supervisor's scoring since 'halo' and 'horns' effects might be averaged out.

5. Conclusions

The differences in marking, for the same pieces of work, are very substantial – worryingly so. Although the sources of this variation have yet to be determined, the evidence so far is that second markers with a limited knowledge of subject content generally tend to give lower marks. There is no evidence that those with higher marking loads on average mark higher or lower than those with lower marking loads, though those who diverge most from the norms generally have lower marking loads. Although the third marker system can be seen as bringing some level of consistency, there are still variations within the marking biases of those who undertake this task and, although not conclusive, there is some evidence that third markers detract from the overall inter-assessor reliability. In any case the arbitrary 10% difference, taken to prompt a third marking, hides cases where first and second marking have been done by two 'easy' markers or two 'hard' markers.

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Appendix

Table A1: Markers relative biases by number of dissertations marked

Marker	Δ	Number marked		Marker	Δ	Number marked
		556		61	-0.40	11
3	-22.00	3		72	-0.40	5
2	-18.00	3		17	-0.33	3
13	-13.40	5				
80	-11.25	4		78	0.00	3
19	-11.00	2		12	0.07	3
29	-10.00	3		41	0.30	6
43	-9.50	2		91	0.30	3
79	-8.17	3		63	1.27	11
58	-8.00	3		76	1.50	4
71	-7.98	8		9	2.20	1
59	-7.67	3		73	2.25	4
65	-7.33	3		36	2.43	21
88	-7.33	2		49	2.67	3
26	-7.00	5		40	2.68	12
62	-7.00	2		35	2.80	10
18	-6.67	3		81	2.90	5
55	-6.50	2		46	3.00	3
38	-6.38	20		85	3.00	3
69	-6.33	3		23	3.20	18
6	-6.17	3		77	3.25	10
28	-6.13	19		8	3.30	10
31	-5.67	3		48	3.67	3
90	-5.67	15		74	4.33	3
32	-5.33	3		52	4.36	7
16	-5.00	3		82	4.55	11
89	-5.00	3		1	4.90	3
42	-4.83	3		30	5.40	10
51	-4.67	3		56	5.40	20
53	-4.40	5		83	5.77	11
33	-4.33	3		92	6.00	3
47	-4.07	15		21	6.17	6
60	-3.67	3		54	6.17	3
75	-3.67	3		84	6.20	5
27	-3.00	3		34	6.77	3
15	-2.67	3		44	6.80	10
66	-2.50	6		57	7.13	8
4	-2.33	3		11	7.58	3
22	-2.28	21		86	8.50	4
39	-2.17	3		50	9.50	2
68	-2.00	3		45	10.17	3
70	-2.00	3		14	10.33	3
37	-1.44	19		7	10.50	2
20	-1.00	3		25	11.00	2
10	-0.82	19		93	13.00	3
24	-0.69	19		64	14.33	3
67	-0.67	3		5	14.40	5

Table A2: Markers relative biases by marker type

Marker	Δ	type	No marked		Marker	Δ	type	No marked
					3	-22.00	D	3
					2	-18.00	D	3
38	-6.38	A	20		19	-11.00	D	2
28	-6.13	A	19		29	-10.00	D	3
47	-4.07	A	15		43	-9.50	D	2
22	-2.28	A	21		79	-8.17	D	3
37	-1.44	A	19		58	-8.00	D	3
10	-0.82	A	19		59	-7.67	D	3
24	-0.69	A	19		65	-7.33	D	3
91	0.30	A	3		88	-7.33	D	2
36	2.43	A	21		18	-6.67	D	3
23	3.20	A	18		55	-6.50	D	2
56	5.40	A	20		69	-6.33	D	3
44	6.80	A	10		6	-6.17	D	3
					31	-5.67	D	3
					90	-5.67	D	15
13	-13.40	B	5		32	-5.33	D	3
80	-11.25	B	4		16	-5.00	D	3
62	-7.00	B	2		89	-5.00	D	3
41	0.30	B	6		42	-4.83	D	3
9	2.20	B	1		51	-4.67	D	3
73	2.25	B	4		33	-4.33	D	3
77	3.25	B	10		60	-3.67	D	3
52	4.36	B	7		75	-3.67	D	3
83	5.77	B	11		27	-3.00	D	3
84	6.20	B	5		15	-2.67	D	3
57	7.13	B	8		4	-2.33	D	3
14	10.33	B	3		39	-2.17	D	3
25	11.00	B	2		68	-2.00	D	3
					70	-2.00	D	3
					20	-1.00	D	3
71	-7.98	C	8		67	-0.67	D	3
26	-7.00	C	5		17	-0.33	D	3
53	-4.40	C	5		78	0.00	D	3
66	-2.50	C	6		12	0.07	D	3
61	-0.40	C	11		49	2.67	D	3
72	-0.40	C	5		81	2.90	D	5
63	1.27	C	11		46	3.00	D	3
76	1.50	C	4		85	3.00	D	3
40	2.68	C	12		48	3.67	D	3
35	2.80	C	10		74	4.33	D	3
8	3.30	C	10		1	4.90	D	3
82	4.55	C	11		92	6.00	D	3
30	5.40	C	10		54	6.17	D	3
21	6.17	C	6		34	6.77	D	3
86	8.50	C	4		11	7.58	D	3
5	14.40	C	5		50	9.50	D	2
					45	10.17	D	3
					7	10.50	D	2
					93	13.00	D	3
					64	14.33	D	3

Table A3: Marking Criteria

Element	Criteria	Comments	Marks
Introduction: Aims and Objectives	• An abstract • A clear description of the project • A clear explanation of the aims and objectives • A reasoned statement on the significance of the topic • The limitations of the project		/10
Methodology	• A description of the characteristics of the data • A description of the process or processes for gathering data • Justification for the method or methods of data collection		/10
Background Review	• An overview of the wider context within which the project is set • A summary of the background literature • Evidence of an understanding of background literature and its relevance		/20
Main Content and Critical Analysis	• Appropriate, adequate and relevant data • Coherent, reasoned analysis and evaluation of data, issues, concepts and views • Evidence of creativity, originality and reflection in discussing, structuring, analysing and reviewing data		/25
Conclusions	• Demonstration that the aim and objectives have been achieved • Conclusions and recommendations which are shown to flow from the critical analysis and evaluation of the data • Evidence of an ability to show the interrelationships between the data and personal evidence-based comment and opinion		/20
Presentation	Appropriateness and quality of the following? • Structure, layout and clarity of presentation • Use and clarity of language, and grammar and spelling • References and system of referencing • Use of diagrams, tables, illustrations and appendices		/15
TOTAL	General comments on dissertation:		/100

11-161
Session: workshop/seminar

Teaching algebra to engineering freshers in three week

Larissa Fradkin, Sound Mathematics Ltd, 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, limited memory, limited proficiency in explanatory reasoning, limited interest in the subject and on top of that, limited time to cover a large amount of material and limited study skills, all aggravated by a limited contact with teachers. Yet, these disadvantages can be overcome when dealing with adult learners. The seminar will be devoted to a specific approach, based on Socratic Dialogue and Eulerian Sequencing, to teaching all the algebra that an engineering student needs in just three weeks. Common student misconceptions will be discussed and ways to overcome them. Progress will be reported in developing a Cognitive Tutor e-PACT (electronic Personal Algebra and Calculus Tutor) based on the above ideas. As such the seminar will touch on the conference themes of global challenges to engineering education, the changing HE environment, student engagement, enhancing engineering education and exploiting technological change.

Integration in Curriculum Development

P. Lahti, [2]P. Pietikäinen, [3]J. Suviniitty, [4]K. Vahtikari, [5]K. Vilonen
The School of Chemical Technology, Aalto University, Espoo, Finland,
pia.lahti@aalto.fi[1]; pirjo.pietikainen@aalto.fi[2]; jaana.suviniitty@aalto.fi[3];
katja.vahtikari@aalto.fi[4]; kati.vilonen@aalto.fi[5];

Abstract

Integration is a specific goal in several universities currently. The School of Chemical Technology in the Aalto University (formerly known as the Faculty of Chemistry and Material Sciences, Aalto University) saw the need to develop a new Degree Program of Bioproduct Technology (BPT). The new Program accepted its first students autumn term 2010. The development work has been conducted in an extensive cooperation within the School and the University for over two years and the development work still continues.

In the early stage of the development process it was realized that certain principles provide scaffolding to all work in this Program. One of these principles is integration. It was understood that all sorts and levels of integration is needed to create a Degree Program that is able to meet the requirements the working life sets for our graduates. Integrating natural sciences into professional subjects, integrating English into other courses, integrating working life skills within all the courses, as well as providing teaching of what can be called tools-of-the-trade, for example mathematics, within the Degree Program themes has been the guiding principle in the development work. Our Workshop on Integration includes four points of view on integration within BPT.

The first case is about integrating working life tools, such as using mathematical programs, learning co-operation skills, how to prepare presentations etc., into courses. The second case discusses the attempt to integrate English with a Natural Fiber Material Science course and how students view this possibility. Case number three is a new course at BPT Degree Program that builds bridges between different kinds of materials. The students' knowledge on basics of material science in general, as well as broader knowledge in the field of synthetic polymers, increases their competence as future engineers in FBI. The fourth example of integration is the aspects of sustainability during an optional course Insights for Sustainable Development in Technology, Economy and Art. This course offered views to the sustainability from the technological, ecological, economic, social and cultural perspectives, which were further processed in students' reflective journals.

With these we will build a starting point to our workshop. The objective of our Workshop on Integration is to share experiences gained during the development work and, in cooperation with the workshop participants, to further establish tools to other curriculum developers for easier integration.

1. Introduction

The need to develop a new Degree Program in the Department of Forest Products Technology at the Aalto University School of Chemical Technology offered an excellent opportunity to integrate several important perspectives in the curriculum. In the beginning of the millennium the driver for the curriculum development in the Department of Forest Products Technology was internationalization. Already then several supporting aspects, such as English language, were integrated in the majors of Forest Products Technology.

The driving force for the recent development work was the structural change that Forest Based Industries (FBI) has been undergoing lately which also reflected in the universities both in reoriented research and lowered amount of applicants. A broader view was needed and this meant moving to a broader conception of biomaterials instead of traditional forest products and their raw materials.

The new Master's Program of Bioproduct Technology (BPT) accepted its first students in the autumn term 2010. The development of this Program was conducted in an extensive cooperation within the School and the University for over two years and the work still continues. One of the guiding principles of the development work has been integration. The project group stated in the early stage of the process that all sorts and levels of integration is needed in order to create a Degree Program that is able to meet the requirements the working life sets for our graduates.

Recent research in the field of engineering education also supported the perspective of integration. Based on the social constructive learning theory, learning is seen as an interactive building process of knowledge, skills and attitudes [1]. In order to implement the learned concepts, the context in which they are learned is crucial.

For example skills studied and practiced in an unnatural environment are not so easily transferred into the real working life situations [2]. It is also known that studies are clearly more motivating for students if the issues to be studied are connected with real practical working life situations or their simulations. Problem or project based learning are examples of how to integrate the study content with various skills and abilities [3]. Based on those observations, it is a very important issue in engineering education to embed different general skills with the engineering content. In the current information society it is also noticed that basic information is outdated so soon that it is much more important to teach the process of acquiring new information than to merely study a particular content [4].

There are several ways to implement integration in curriculum development. The most systematic and well-know is the CDIO-approach.[5] However, following the CDIO is not possible for all universities for a number of reasons and other methods are also needed. In this paper we introduce four cases that show how integration has been implemented at our School. First we will describe how the integration has been included in the curriculum development work, then we discuss integration of English into all of the Master's Program courses and finally we introduce two course examples where integration has played an essential role. The first course is an obligatory course for all the BPT students and the second is an optional course that has attracted a significant amount of BPT students.

Our cases will build a starting point to our workshop. The objective of the Workshop on Integration is to share experiences gained during the development work. The key questions are: What can be integrated? What the participants of the workshop have integrated? What was needed to succeed in the integration? What have been the most challenging aspects in the integration? Our aim is, in cooperation with the workshop participants, to further establish tools to other curriculum developers for easier integration.

2. Case 1: Integrating working life skills and tools

2.1 Internationalization

This case explains how working life skills and tools, such as using mathematical programs, learning co-operation skills, presenting technical data etc., have been integrated into BPT courses.

The Department of Forest Products Technology began to consider integration of working life skills into its curriculum in more detail in the beginning of the millennium. Graduates from the Department entered working life and started to work in the companies that operated not only in Finland, but in Europe and outside Europe. One could work in a very small Finnish city far away from the capital area and still use English daily while at work. The ability to communicate in the international working environment was defined as one of the skills students should learn when they were studying in the Department. Being able to communicate does not require mastering a language, but it consists of a desire and competence to relay a message to others on various issues.

Discussions between the Head of the Department and the companies of the Forest Products Cluster lead to an intensive, five-year development project after which all the courses at the M.Sc. level were taught in English. Language was not the only aim of the project, but also the scope, the goals, the contents and the outcome, as well as the teaching methods of the courses were reviewed. The reason for the extensive development effort was the Department’s desire to educate competent engineers who are capable of working in dynamic positions both in Finland and abroad.

The representatives of the companies involved in the development project had regular meetings with the planning group of the Department. There were students in the group along with the professors, study administrators and project engineers. The group discussed what needed to be done, but also why the tasks were necessary.

The Head of the Department encouraged the teachers in the Department to develop their teaching skills already in the late 1990’s. The development of teaching skills became more systematic along with the teaching in English, because the Department wanted to support students' learning also through improved teaching methods. Approximately 10 teachers accomplished University Pedagogics (YOOP), 30 ECTs of voluntary pedagogical training offered by Helsinki University of Technology during the internationalization project and approximately another 15 teachers after that. Shared experiences of the modern teaching methods encouraged teachers to try new approaches in their courses. This meant motivating students to work in groups, using Problem Based Learning (PBL) method, including reflective journals in the courses, giving more feedback to students on their tasks (e.g. reports, presentation, group work). Wider projects were also introduced in the courses.

Sometimes motivating meant forcing, because students tend to persist using their familiar working habits. However most feedback from the students was positive and this together with improved results encouraged the development process to persevere.

2.2 Broader perspective

The vast development work implemented in the beginning of the 2000’s in mind, it was fairly easy to start planning a new Program, the Bioproduct Technology Degree Program in 2008. In the new Program the integration of working life skills, such as mathematics, communication and group working skills are systematically planned when it has been possible.

Mathematics, chemistry and physics are all compulsory studies in the BPD Program. Traditionally in the Finnish engineering studies these topics are considered important when the Programs are planned but the students do not find the connection between natural sciences and their own study field and therefore do not find the natural sciences motivating. It is also a tradition that most of the mathematics, chemistry and physics courses are taught during the first study year and most of these courses offer slight, if any, connection to the topics which actually interest the students.

In BPT the mathematics studies are planned to be synchronized with other studies to ensure that the mathematical tools needed for some other courses are available to the students when they need them. The mathematics teacher uses examples from the Bioproduct industry and the teacher is also able to visit other courses when the mathematics tools are used for the first time. All these actions are thought to help the students to apply their mathematical skills as required. Earlier this connection has not been good and teachers of other subjects have been forced to teach mathematics in their courses. All this development work is implemented in close cooperation with the Institute of Mathematics and could not be completed without it. As only the first year of BPT studies is completed, the results cannot yet be verified. However, already it is known that more students have completed their mathematics studies according to the schedule than before.

Prior to this development work, a vision paper was created by interviewing 30 FBI experts and by analysing several relevant publications and policies, such as the EU 202020-paper [6]. The vision 2020 paper clearly showed that the communication skills are one of the most important skills for practising engineering in FBI in the future. Therefore the communication skills are practised within several courses. Already from the very beginning the students have several presentations per semester, first in groups and later individually. The students have already said that this beneficial to them.

Group work is another of the skills that is practiced throughout the Program. It also starts with low-risk group work and develops into well-structured project organization where everyone has their own roles, such as a manager or a coordinator.

Since most of the BPT courses are new and many of the teachers have had pedagogical training, the need for integration was accepted and the courses were developed considering this. The very fruitful co-operation between the disciplines has also been essential in order to develop mathematics or other courses, such as the polymer and material course that is later explained in more detail. This level of integration requires coordination that is approved and facilitated by the Head of the Program. Another requirement is that the students take their courses in the order planned in the Program. This is a significant change in the Finnish university system, which has allowed more freedom for the students on scheduling their courses.

3. Case 2: Integrating English

The Department of Forest Products Technology was one of the first departments at Helsinki University of Technology which adapted English Medium Instruction (EMI) and it still is the only one which offers teaching only in English, with no parallel courses in Finnish. This was seen as both a benefit and a threat at the beginning, but through the years we have seen many successes as a result. Currently seven of the Department's professorships are held by international (i.e. not Finnish) professors which gives the students no other choice than to communicate with their professors in English. Graduating students spontaneously comment on how much their English skills have improved when they have been "forced" to use English on a regular basis in their activities.

As we know, FBI have always been international with both import and export foci, while the recent developments have made this even more so with mills and other facilities being built mostly in other parts of the world and not in Finland. Since the business partners come from various parts of the world, English is usually the lingua franca used in communications between them. When the latest developments in processes and other research are reported in English, the scientific and academic audience is much wider than when the reporting is completed in Finnish. These reasons clearly guide the choice of the language and thus even the new, Bioproduct Technology Degree Program is an EMI program.

Since all the courses in this Master's Program are held in English, students are exposed to English, at least passively, on a daily basis. This is similar to situations in CLIL [7]. CLIL teaching has shown beneficial results on especially content learning. It is not absolutely clear why some studies indicate that the content learning in CLIL teaching is superior when compared to regular teaching, but researchers suggest that as students have to concentrate more because of the foreign language, they also concentrate better on the content itself. CLIL teaching is, however, quite a controversial issue which is continuously discussed and even criticized. In this case, however, the content and English will be taught by different teachers and the cooperation between these teachers will not be as intense as in CLIL.

Despite the original controversy on EMI, the new BPT Program operates in English. Students are also required to complete three credits of international language studies at an advanced level [8]. This language for most students is English. As the new Program and its possibilities were discussed, an option of integrating the required English studies with another course emerged. The integrated English course was discussed with the Language Center as well as the School Academic Affairs. As a result of these discussions, the new, integrated English course is in its planning process and will be implemented for the first time in the autumn semester 2012.

Students were also asked for their opinions on having English as an integrated part of their other course or courses. Unfortunately the response rate on the paper-based student questionnaires was very low as we received only 16 responses. Most of the respondents (12/16) showed great interest in this, as they could concentrate on the subject matter more while developing their English skills. Interestingly enough, some students (4/16) preferred to have a separate English course rather than an integrated English course. A course where students need to complete reports as well as present the results to the rest of the group seemed ideal for the purpose of the integrated course. Since the language requirement is only three credits, this can be integrated into the subject course which runs over two periods and thus allows for student development already during the course.

Most language courses are run during one six-week period which only allows a superficial approach on most issues discussed during those courses. Students can be made aware of certain issues but actual changes and transfer effect usually occurs only after the course. One of the goals with the integrated English course is to develop the topics further with the longer time frame and to gain the transfer effect from the discussed language issues immediately when working on the course assignments.

We, naturally, expect the results on this course to be perceived as beneficial and we intend to ask students' feedback specifically on how they view the integrated English and its influence. The earliest we are able to report on these results is 2013, but we look forward to favorable views on our carefully planned work.

4. Case 3: Integrating material science

Case number three is a new course at BPT Degree Program that builds bridges between different kinds of materials. The students' knowledge on the basics of material science in general, as well as their broader knowledge in the field of synthetic polymers increases their competence as future engineers in the FBI.

This integration takes place in two courses, one of which is theoretical and the other is practical. The theoretical course starts with an introduction of the field of materials science in general, the variety of different kinds of materials and the most important parameters characterizing their nature. After these general issues the focus of the course shifts into synthetic polymers. The basis of the course development is five years of experience in teaching the basics of polymers to students in Degree Programs of Chemical Technology, Materials Science and Bioinformation Technology.

Students from different Degree Programs naturally have their own kind of focus in their studies of materials science and technology. This has been seen in a concept study [9]. This study demonstrated the idea of the meaning of the Degree Program on students' identity already in the very beginning of their studies. It is important for the teacher to be aware of students' underlying thoughts about the taught subject matter to be able to enlighten the studied area from reasonable points of views. The situation in which teachers of polymer technology from the Department of Biotechnology and Chemical Technology go to the Department of Forest Products Technology and start to teach their topic without taking into account students' attitudes towards, for example, the usefulness of the subject area possibly leads to an unfavorable situation related to learning. It is important that teachers are able to integrate themselves in the entity of the individual course.

Students' thoughts of the learned subjects are to be integrated into larger entities than just the studied courses. Many students, especially in their first study years, seem to take the courses as blocks which do not necessarily have anything to do with each other. The teachers must recognize this and work on the idea of integrating courses into larger wholes in the Degree Programs and also integrate the learned material in the surrounding society. Materials Science is a good example of a subject that touches everyone daily: each item we use is made of some material and there is a specific reason for each material selected for their purposes. Sustainability being a growing idea today, we all have to make decisions regarding this. Therefore, the focus is not merely on students' professional development but also on them becoming responsible customers

Learning is activated by weekly assignments which replace the conventional exam. Discussions and plenty of sample material are also used in the course.

The practical course supports the issues presented in the theory course. It pertains to measuring of properties from error analysis to standards, and the development of results from measurement data. The aim of this short course is to introduce the basic phenomena and show the differences in the behavior of different kinds of materials from wood to metals and from paper to thermoplastic polymers.

5. Case 4: Integrating multidisciplinary approach of sustainability

Sustainability is one of the core subjects in engineering education and it is included in many courses within the curriculum. However, quite often in the engineering education, sustainability is seen only from the technical point of view although that is only one side of sustainability, as it also includes social, cultural and economic views. In order to obtain a full picture of sustainability multidisciplinary studies integrated in all levels of engineering education are required. Furthermore, the wide range of knowledge related to sustainability demands both system and critical thinking, supported by creativity together with communication, interaction and group working skills, integrated in major studies.

Case four, the course Sustainable Development of Technology, Business, Art and Design, represents one example of multidisciplinary integration of sustainability into Bachelor Majors in engineering, business, art and design [10]. The course was created in co-operation between three different Schools of Aalto University, the School of Science, the School of Economics and the School of Art and Design and it was offered as an optional course to all first year students. However, due to the very heavy work load of the first study year, less than 10 % of students attended this optional course. One exception was the Degree Program of BPT, where 20 % of students participated in this course. This might be partly because of the topic, which is strongly related to the learning goals of BPT and partly also because of the second and third year students who changed their study program from old Forest Products Technology to the new BPT and they probably had more time in their schedules.

The goal of the course, Sustainable Development of Technology, Business, Art and Design, was to enforce and guarantee long term orientation and motivation for sustainability with social, economical, technical and cultural views. Another goal was also to integrate teaching of the first year topics to significant research topics and build the elements of an academic community among students, university staff and faculty.

The course was offered in a form of lecture series and those lectures were given by professors from different disciplines, such as national economy, international trade, new media, graphical design, nanotechnology, brain research, energy, ICT, water management and recycling technology. Students' thinking was supported by reflective journals, written weekly after each lecture, and commented by teaching assistants. Students were encouraged to discuss the topic of the weekly lecture also outside the lecture hall with each other.

The analysis of the students' reflective journals shows the importance of linking the content both to their studies and also to their everyday lives, based on the constructive learning theory of knowledge building. The everyday life aspect seemed especially important for the first year students: they very often reflected on their previous experiences with the content presented during the lectures. This personalization is important also to their motivation: students need to understand the importance of the content for them to be highly motivated. Students usually have a career in mind already in the beginning of their studies. This goal for studies can change, but it guides them and provides perspective in order to reflect new information from their courses. Linking new issues, even remotely, to their personal goals is a source of motivation, for example engineering students started to be interested in economy after the lecture when they realized that economical aspects are also part of working life skills and sustainable development.

Another important issue regarding students' motivation was the novelty value of the contents presented during the lectures. Students were immediately more interested in the topic if it was novel enough, even if they did not find clear link to the topic in their own studies or personal life. Furthermore, in addition to content novelty, students also appreciated the expertise of the lecturers. The professors with long experience in their research fields were able to present different perspectives with personal opinions supported by well-explained facts. Those different perspectives and comparison between them, together with real life examples, made comprehension of specific topics easier than mere theories. Students also managed to link the content to their own interests easier.

This lecture series, given by professors from very different disciplines, was an attempt to utilize the multidisciplinary scenario of new Aalto University – a combination of science, technology, economics, art and design. During the first year linking the study content was more challenging than when the course was offered the second time. This was probably because most of the lectures were the same both times and on the second time they knew more about their colleagues' presentations and were able to present sustainability as a linking factor. The coordinators of the course were also more familiar with the course entity and they were able to offer ideas to help in linking the content between lectures and find different aspects of sustainability when they were commenting the students' reflective journals. This type of personal guiding can play a very important role in making integration of different contents easier to students although it requires teacher resources. However, sometimes small issues, such as an introduction of lectures with a few sentences already created a certain bridge between different topics. Questions given to students may also help them to find linking, for example, between designing of commercials and sustainability, which was not so self-evident, although those are related by consumption habits and people behavior.

6. Conclusions

As our cases show, integration is possible within one course and between courses. Program-wide integration is, naturally, more effective. As stated in our first case, the need for integration must be identified and accepted widely, since the change between "the old way" and the integrated way is large. If the Head of the Program does not understand the need for rethinking old structures, the required work seems too complex.

The change requires the teachers involved in planning to have pedagogical skills. In our case the need for pedagogical training was realized already in the beginning of the millennium and, therefore, we had sufficient amount of knowledge to implement the BPT Program.

Integrating language with content is nothing new. Despite this, it is less common at Aalto University School of Chemical Technology than you would expect. Working differently from others and changing the way things have been done in the past requires more work, but should also benefit not only the students but also the staff.

As stated in cases 3 and 4 integration requires co-operation and knowledge sharing between teachers and disciplines. This, nevertheless, cannot occur without time and thorough discussions. The start is slow, but the results, more motivated students and usually better learning, quite often speak for themselves.

We aim to also learn as we implement the integration in these different cases. The goal is to be a learning organization which can modify those aspects of courses or Program that seem not to work while developing those aspects even further that provide favorable results. Being open and active while asking for feedback and comments should help us reach our desired goal for students and thus also for our benefit. Integration moves the idea of teaching towards systems thinking. High quality teaching cannot be separate actions of individual teachers inside their own vicinities e.g. research groups, majorities or even Degree Programs. High quality teaching is systematically planned, well resourced and carried out in wide co-operation.

7. Acknowledgements

The group would like to thank our colleagues who have been actively developing and integrating all these years.

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Experience of professors with an electronic teaching environment for hybrid/remote teaching

Jean-Marc Robert, Walter de Abreu Cybis
École Polytechnique de Montréal, Canada {jean-marc.robert, walter.cybis}@polymtl.ca

Abstract

This paper presents the user experience of professors with an electronic teaching environment for doing hybrid/remote teaching in several Human Factors Engineering courses at École Polytechnique de Montréal. We investigate some problems with the functionality and usability of the VIA software environment and we propose guidelines to solve them and improve the user acceptability. The main problems are concerned with the set-up time of the environment at the beginning of each course period (a minimum of 32 operations which may last between 5 and 8 minutes each time), the constraint of using only static material on slides presented to students, the difficulty to go back and forth between the course material and the Internet during the course, the poor interaction with remote students, and the limitations of the equipments (camera and microphone) that have to be installed in class for remote teaching.

1. Introduction

Over the last four years, we have been teaching several courses in Human Factors Engineering at École Polytechnique de Montréal, simultaneously in class and remotely through the collaborative software Via eLearning & eMeeting (VIA). In this hybrid/remote teaching, the professor is physically present in the classroom for teaching to students who come to the campus, who are available during the course period, and who prefer to attend a course in class. At the same time, s/he is present online, through Internet, for teaching to students who cannot come to the campus, who are not available during the course period, or who prefer (or are constrained) to attend a course at a distance. The remote students can see the professor in class, see the material s/he is presenting both on screen and in class, listen to his/her voice and other students' voices, and ask questions verbally or by writing. All the students have access to the course material and course recordings for the duration that is decided by the professor.

In this paper we report our experience with VIA software system. We analyze problems encountered with the functionality and usability of VIA and propose guidelines to solve them and improve the system user acceptance. Even though these problems are specific to VIA, in our opinion they are likely to exist in other similar systems so that the guidelines that flow from the problems should help system designers.

This article is structured as follows. First we define the objectives we pursue with hybrid/remote teaching, and present some characteristics of hybrid teaching. Then we describe the operations the professor has to perform with the VIA environment at the beginning of each course period. After, we present the problems encountered with VIA and the guidelines we propose to solve them. As conclusion, we take a stand on the future of hybrid/remote teaching in our courses.

2. Objectives of hybrid/remote teaching

We pursue three categories of objectives with hybrid/remote teaching, depending on the stakeholders that are considered: the students, the professors, and the university (Robert, 2010)

For the students:

- **Flexibility** both in space and in time so as to allow students to attend their courses at the place and time of their choice. This is essential for students who have part-time or full-time jobs during their studies. They often have difficulty to attend a course on a regular basis, i.e. at the same period of time each week during 15 weeks, because of important work deadlines, team meetings, visits to clients, business trips abroad, etc.
- **Accessibility** for students who live too far from the campus and do not have access to similar specialized courses in their region, and for students who may not be able to come to the campus because of family charges, sickness, physical handicaps, or other personal restricting conditions.
- An opportunity to learn how to use the technology that supports remote teaching.

For the professors:

- Have a larger audience and recruit students, especially from far regions and from abroad;
- Have more visibility in their professional community and their society;
- Acquire experience in remote teaching and with the technology that supports it.

For the university:

- Accomplish its educational mission more broadly;
- Be more competitive in front of other universities;
- Give more visibility to its professors, courses, and study programs;
- Recruit more students in far regions and abroad;
- Increase its revenues.

As with remote laboratories in engineering (Hariz & Mohtar 2010), there have been wide debates regarding the effectiveness of remote teaching in general and whether it can truly replace or complement teaching in class. With adequate resources and material, it can be very successful.

3. Hybrid teaching

An initiative of hybrid teaching depends mostly on the quality of the resources supporting the realization and the capture of lectures as well as the provision of the lectures captured. In fact, according to “The Campus Computing Project” (2010) the investment on technologies for the capture of lectures is considered as one of the three most important initiatives aimed at the development of instructional materials for 60.5% of U.S. universities. Two other major initiatives considered by American universities are electronic books (86.5%) and mobile applications (70%). Meanwhile, only 4,4% of the universities surveyed make use of lecture capture technology.

In a similar proportion, at École Polytechnique de Montréal, very few professors (15 out 220 - 1,82%) give their courses in a hybrid/remote mode. This may be due to several reasons: increase of the professor’s workload, lack of motivation, lack of encouragement from university, skepticism towards the effectiveness of remote teaching, reluctance (for some professors) toward the potential negative use of recorded courses by the students and even the university, and the lack of functionality and usability of the VIA software environment. This last reason is major because, as it will be shown below, it affects the professors’ workload and frustration, the quality of the course material, and the quality of learning for the students. So it deserves an investigation.

In this paper, we report our user experience with the functionality and usability of the VIA environment. It is important to notice that VIA is constantly evolving, and that the evaluation we carried out refers to the version available in May 2011. Our experience is based on the use of VIA for teaching one undergraduate and four graduate courses in Human Factors Engineering during four years. Each course consists of 15 periods of 3 hours each, and is principally a lecture with several interactions with the students. On average, there are 90-100 students per group in the undergraduate course, and 15-20 students per group in the graduate courses. For results on attitudes, beliefs, and attendance in a hybrid course, see Yudko et al. (2008).

4. The professor’s activities for creating a teaching activity in VIA

To create a teaching activity on VIA, for each period of course the professor has to do the following operations:

1. Enter Moodle
   One sees the list of documents to which s/he has access.
2. Select the course for which you want to create a teaching activity (click on course title)
3. Activate the edition mode (click on a button)
4. Open the menu “Add an activity”
5. Select VIA – Virtual teaching (in a combo box)
   One sees the Window “Via – Virtual teaching” (see Figure 1)
6. Enter text (Title of the teaching activity)
7. Enter text to describe the activity
8. Enter 3 values to set the duration of the activity (or accept default values)
9. Enter 3 values for the session parameters (or accept default values)
10. Enter 1 value to Register the participants (or accept default value)
11. Enter 4 values for Common settings of the modules (or accept default values)
12. Click on “Register and come back to the course”
    One sees the window “General view of the sections”
13. Click on “New teaching activity”
    One sees the window with general information
14. Click on “Click here to access the activity”
    One sees the window “Beware: This activity could be registered. ...”
15. Click on “I accept to access this activity and be registered” Or “I refuse to access to this activity”
    One sees the window of the VIA system
16. Click on “Manage the documents”
    One sees the window to choose an option
17. Click on “Import from my computer” or “Import from my VIA documents”
    The window shows the list of files on my computer
18. Select a file to transfer into the teaching activity on VIA
    One waits for the loading time depending on the size of the file
19. Click on the selection box “Make public”
    Repeat steps 17, 18, 19 if there are other files to transfer into VIA
20. Click on “Terminate”
21. Click on the icon of the camera
    One sees the window “Configure the camera”
22. Select a camera in the menu
23. Click on “Activate”
24. Click on the icon of the microphone
25. Click on “I hear the music”
26. Click on “Activate”
27. Adjust the sound level
28. Open the PPT file for the course
29. Reduce the chat window
30. Set the parameters of the main window (3 clicks)

If one adopts the default values in steps 8, 9, 10, 11 and transfers 3 files to VIA (which is typical for a 3-hour course, and which means doing the steps 17, 18, 19 three time), there is a minimum of 32 operations to do; they last between 5 and 8 minutes, depending on the number and size of the files to transfer to VIA. Figure 1 shows an example of screen of VIA that can be seen by the professor and the remote students.

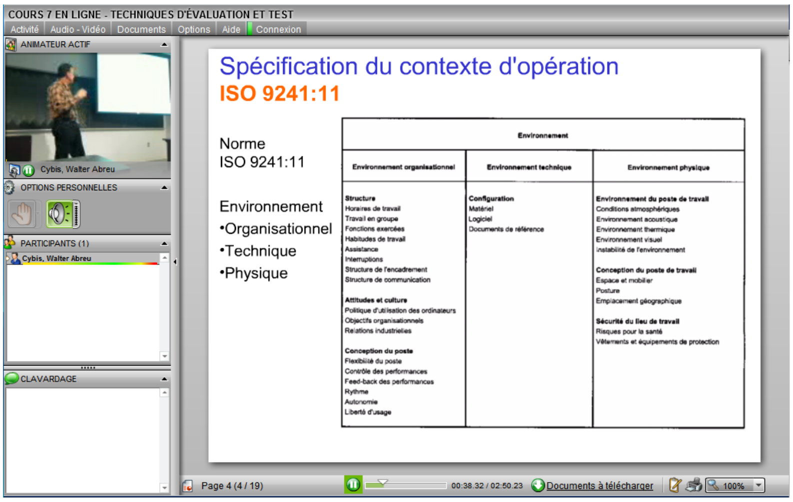

Figure 1: The VIA module for lecture visualization.

5. Problems and Guidelines

In this section we describe some problems with the VIA environment, we evaluate their impacts on the quality of teaching and on the professors' and students' activities, and we propose some guidelines to solve them.

Problem 1: With VIA, the course material shown in the PPT (PowerPoint) slides must be static, otherwise there are problems of use. This is a major weakness because there is strong tendency to present more and more dynamic material (e.g., animations, video) during courses. It is a constraint for the professor who builds the course material, and a limitation to the quality and modernity of a course. Since the presentation of dynamic material aims at improving the quality and interest of a course and at facilitating the learning activity for the students, its absence is likely to have a negative impact on students.
Guideline 1*:* Use a software environment that easily supports the presentation of dynamic material (e.g., animations, video) in course material.

Problem 2: With VIA, the back and forth movements between the course material on PPT and different Web sites that are visited during a course are not easy. The professor has to do cumbersome operations that are time consuming, increase his/her workload and finally discourage him/her to go often on Internet during the course. This is a source of frustration for the professors and it is to the detriment of the quality of a course and of the learning experience of the students.
Guideline 2*:* Use a software environment that easily supports Web surfing during courses and that permits rapid back and forth movements between the course material and the Web.

Problem 3: Due to a lack of integration between VIA and Moodle, the professor has to deposit the same course material both on Moodle (for students who attend the course in class) and on Via (for students who attend the course remotely). This activity is time consuming and increases the professor's workload, besides being perceived as repetitive and useless. And most of the time, it is done just before the course, at a critical time because the professor is busy with the final preparation of the course and would prefer to focus on what is more important.
Guideline 3: Use a software environment that does not increase (or minimize) the workload of the professors, either in time (through the number of operations to do) or in complexity.

Problem 4: With VIA, the interaction with the remote students is a bit awkward for different reasons. When a remote student asks a question by writing (N.B.: some students use the microphone of their computer and ask their questions verbally), the system makes a buzz, the professor has to go to the computer, click to enlarge the chat window (in the middle of the left

column of Figure 1), read the question, answer verbally, check if the student is writing comments or another question, wait for them, if any, answer again, and finally click to narrow down the chat window. This breaks the flow of the course and it is time consuming. If remote students were often asking questions during a course, the interaction with them would rapidly become cumbersome and difficult to manage by the professor. Another person would be necessary in the class to manage the questions and comments from remote students.
Guideline 4: Use a software environment that easily supports rapid and natural interactions with remote students.

Problem 5: With VIA, there is an important set-up time of the system at the beginning of each period of course. First, if fixed equipments are not available in the classroom, a mobile camera and microphone have to be installed at the beginning of each course and de-installed at the end; the position of the camera in front of the professor has to be adjusted so as to give the best view to remote students. Second, the professor has to perform several operations (see section 4 above). These operations are time consuming, done at a critical time (because it is the beginning of a course), and done *in live* in front of the students who can follow on the screen what the professor is doing, sometimes with errors... The professor has to memorize these operations since there are no guidelines on screen.
Guideline 5: Keep the set-up time of the equipment and the system as low as possible. If possible, use fixed rather mobile audio-video equipments for remote teaching in order not to have to install, de-install, and adjust them in class for each course period. Keep the number of operations for the set-up of the system as low as possible (if impossible to automate). Make sure that the operations to be done by the professor for setting the system are transparent, otherwise, provide a clear procedure.

Problem 6: With VIA, a camera must be placed in front of the class (usually on the first row of the students' desks) and oriented toward the professor to capture his/her face and gestures, the objects that s/he might be showing, and the blackboard. So remote students can see what is going on in the classroom. There are some problems with the use of this camera. First, it puts constraints on the size of the surface where the professor can walk in front of the class if s/he wants to remain visible to remote students. Second, the small size of the image shown on remote students' computer screens makes it difficult to clearly see the objects the professor is showing in class. For paper documents, a camera for documents would be much more appropriate. Third, the small size of the image makes it difficult for remote students to read on the blackboard. As a consequence, the professor should minimize or eliminate the use of a traditional blackboard in class. This is a constraint for the professor and to the detriment of the students in class.
Guideline 6: Use a high quality camera, especially if the professor shows objects in class and uses a traditional (or non interactive) blackboard. If paper documents are frequently showed in class, use a specific camera for documents. If other types of objects are frequently showed in class, use a specific camera to show these objects. If there is traditional (non interactive) blackboard in the classroom and if it is visible only through the camera placed in front of the professor, minimize its use because of the poor readability of the information presented on it for remote students.

Problem 7: With VIA, a microphone must be placed in front of the professor to record his/her voice and that of the students in the classroom. So the remote students can hear the professor's voice, and in principle, the questions/comments of the students present in class and the discussions between the professor and these students. Actually remote students have difficulty to hear the voice of the students who are sitting far from the microphone in class. Ideally, the professor should repeat the questions and comments for remote students but this is rarely done, or partially done; furthermore, it is almost impossible for the professor to repeat the discussions between the students.
Guideline 7: Use a high quality microphone in class. If the classroom is large, use several microphones to better capture the voices of the students.

The functionality and the usability of VIA should be improved to reduce the professor's workload, allow the creation of dynamic course material, and improve the quality of the interaction between the professors and remote students so as sot to create a positive user experience for the students.

6. Conclusion

Despite several irritants with the VIA environment, as professors we are globally satisfied with this hybrid/remote teaching experience so that we intend to pursue it in the future. Similarly, despite irritants, remote students assert they are globally satisfied with their learning experience. They encourage us to continue to offer them this service and wish it would be available for all their courses.

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Simulation for Education in Construction and Construction Management

[1]**David Scott,** [2]**Mick Mawdesley,** [3]**Eric Scheepbouwer**
Curtin University of Technology, Perth, Australia.d.scott@curtin.edu.au [1]
University of Nottingham, Nottingham, UK mick.mawdesley@gmail.com [2]
Canterbury University, Christchurch, New Zealand. eric.scheepbouwer@canterbury.ac.nz[3]

Construction is a complex industry. It is particularly important to educate and train people in the procedures and management of the industry. Such training needs to be very broad in order to provide maximum benefit. It also needs to facilitate faster and more reliable learning than the traditional 'learning on the job' which used to be the way of initiating fresh graduates to construction management.

Traditional education and training can only improve some aspects, but simulation has been introduced to broaden the spectrum of and improve the effectiveness of learning to cope with more complex issues that face engineers in the industry. Typically simulations are computer-based and designed to tackle the management of technical aspects of construction. The authors have many years of experience of running courses at various levels using such simulations. However, this type of simulation can lead to a false understanding of the effectiveness of the methods being considered. For example, a simulation designed to 'teach' planning and control will almost certainly neglect the human influence or model it in a simplistic manner. The learner is then likely to acquire a biased or partial view of the effectiveness of the techniques and not appreciate actions that are necessary to use them in practice.

This paper discusses how a computer-based simulation has been used in practice in a number of institutions around the world (U.K., Netherlands, Malaysia, Australia and New Zealand) using simulation. It is based on many years of experience of developing and using IT and non-IT based simulations and examples currently being used are provided to illustrate the arguments. It concludes by suggesting areas for future IT-based development of simulations for education and training.

1. Introduction

It is now widely accepted internationally that the education of engineers must be much more than a technical education. (IPENZ, 2011). A graduate must be equipped for their career as a professional engineer, with all of the attributes that this infers. The Washington Accord (1989), an international agreement for mutual recognition of engineering qualifications acknowledges this. The Accord highlights the need for developing attributes ranging from in depth technical knowledge to the more qualitative management skills, understanding of engineers' responsibilities and the ability to communicate effectively.

All countries whose professional engineering bodies are signatories to the Washington Accord have an accreditation process for university courses that checks for the appropriate inclusion of all elements of a graduate's education. Engineers' academic technical training is completed, in the main by a degree qualification. These degrees have traditionally focused on the technical, more quantitative aspects of engineering.

Less well catered for are the more qualitative aspects of an engineer's learning – the management of resources, processes, procedures, communication, sustainability, people management. For many institutions these areas have been presented using the same techniques as structures, geotechnical and water engineering subjects but this has not been followed through with the same application of theory experience in the way that design is used to give experience in use and application of technical subjects (e.g. structural analysis).

Qualitative subjects (the management of resources, processes, procedures, communication, sustainability, people management etc) need reinforcement by use just as much as technical subjects.

This paper sets out how this has been done in a number of institutions around the world (U.K., Netherlands, Malaysia, Australia and New Zealand) using simulation.

2. Simulation as a Tool in Engineering Education

During the development of engineering competencies and abilities it is particularly important to educate and train students, graduates and junior engineers in the procedures and management of the industry. Such training needs to very broad in order to provide maximum benefit. It also needs to be more rapid than the traditional 'learning on the job' which was the traditional approach to 'management'.

Management-type simulation games have become a commonplace learning tool at all levels of instruction from early school teaching to postgraduate education and industrial training. They are an ideal mechanism for the transfer of knowledge of managing complex systems such as companies, projects and industrial processes without risk (Gilgeous & D'Cruz, 1996; Prensky, 2001).

Simulation is a natural concept for inclusion in engineering education. It removes the costs and risks of the real world whilst enabling people to gain many of the experiences. Therefore, if people can really learn efficiently by experience, simulation should be used. There are aspects of engineering which require experience to really understand and these should use simulation as a teaching / learning tool.

Over the last fifteen years the technology available to games designers has changed beyond recognition. However, it is not solely the increased use of technology that makes the game successful in helping students achieve the desired learning outcome. The purpose of simulation is to create a learning environment that mirrors reality so as to allow the player to develop skills that can be applied in the real world. If the simulation does not appear to act and respond as the real world then the learning will be deficient. Also if the players lose confidence in the reality of what they are doing, and the exercise becomes a game like 'Monopoly', then the value of using the simulation for real learning is lost. This creation of the appearance of reality is called verisimilitude.

Often IT based simulation packages/programs (often referred to as games) are used to create verisimilitude because computational power and speed allows the trainer to concentrate on facilitating the student-engineers' learning. However this can sometimes give a false sense of achievement and the simulation package becomes no more than another computer game. This paper, therefore, has three functions:

1. To demonstrate the types of situations that can be successfully simulated for e-learning.

2. To discusses how to create a simulation exercise that has verisimilitude, sufficient to deliver learning outcomes that develop appropriate graduate attributes

3. To review the success of simulation in achieving appropriate learning outcomes

The simulations presented have been used in the U.K., Netherlands, Malaysia, Australia and New Zealand and are based on construction projects which the players have to manage. The objectives, structures, features and usage of these games are demonstrated by giving examples of how the games are used, the lessons that have been learnt and the most significant and important features.

All of these features are interlinked and interdependent. The simulations developed for the management of construction are used here to demonstrate of how all the parts fit, interact and work together.

3. Experiences using Simulation as the Principle Learning Tool

Simulation can be used effectively for students in university and in industry based training for engineers with some years of experience so the players of the 'games' are able to learn and build on their prior experience. The focus of any simulation should be the learning outcomes. The expected learning outcomes and how they were achieved for specific fields of management and construction management are presented here to illustrate and demonstrate this concept. These observations are based on 40 years of using simulations that have ranged from totally IT based to none.

The simulation games and software that have been developed and that are used here as illustrations are:

a) Muck Game (Dam game) – construction of 30m earth and rock dam,
b) Canal Game – construction of 7km of clay lined canal.
c) IESSG BizSim – A generic business start up simulation (aimed at high-tech SMEs)

Each game has a similar interface and method of working but the scale and complexity of each project is different. Games focus on the planning and control of projects and business with a mix of interactive resources.

a) The Dam and Canal games were designed to be used to teach players about the control of construction. Each has its own challenges and learning focuses but essentially they allow the students to develop skills in planning, monitoring and controlling construction resources of equipment, personnel, time and money

Players are required to develop a plan for completing the project, select appropriate resources, supervision and training and then run the project. They must take appropriate control action, including re-planning, in response to results from the simulation.

An 'Umpire' package that monitors, tracks and reports student performances is also described along with the reasons for its development, its role in teaching and student monitoring

b) The game called BizSim was used to simulate the student's own business plans. This allowed students to 'invent' their own company, to produce a business plan for it and to run it through the first two years of its life.

BizSim consists of two main elements; the Creator tool and the Simulation Game itself. Both these elements draw on a common data model that represents the simulated business environment. The creator tool is used to generate bespoke simulation environments to reflect the start-up companies proposed by the student business plans and the business environment in which they will operate. Once the simulations have been created and extensively tested they are ready to be used by the students who run the Simulation Game.

3.1 The Dam Game – developing engineers' management skills

Dam game will be used to illustrate the essential structure and typical features of a successful simulation. For the sake of clarity the student or engineers who are involved in 'playing' the simulation game are referred to as players and the teacher/mentor/controller who is running the exercise is the umpire.

The game, described in this paper, was designed to teach players about the control of construction – not the construction of earth dams but rather the general and generic principles of construction management, although actual fill calculations, toi be done by players increased the sense of reality of the game.

There were several detailed objectives to be considered in the design of the game. These can be summarised as

- To provide a 'realistic' model of a construction project which will react in physical and financial terms to the decisions made and actions taken by the player
- To provide reports as might be expected on a real project
- To include uncertainty but to control it in such a manner as not to hide the effects of control actions
- The game should, if possible, be suitable for use by both undergraduates and practicing engineers.

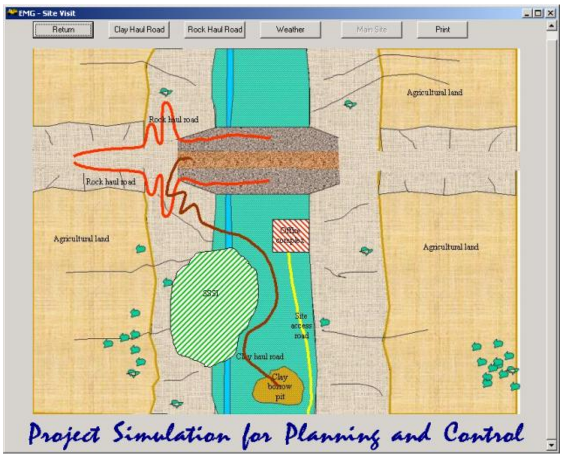

Figure 1: The Dam Game project

One of the main aspects of a project based management game is the project which is modelled. The project must be simple enough to be contained within a game and appreciated by the players but complicated enough to provide a realistic challenge to them. It would be pointless to consider using a project which could not be realistically modelled with the computer system available and it would be counter-productive in terms of motivation if the model were either too complicated or too simple for the players.

In terms of complexity, it is also important that the project must be complex enough to illustrate the intended points whilst not being so complicated that the players will be unable to understand the lessons inherent in it. There will also invariably be limited time to play the game, either because of the limitations imposed by the course or because the players are unwilling to devote any more time to it. This will limit the complexity of the project. Use of IT to run the simulation allows reality to be balanced with complexity of operation.

Figure 1, shows a general sketch of the project generated by the IT simulation package. The project is based on one that was developed for a text-based game a number of years ago and used for undergraduate teaching for a number of years.

The dam is rock-fill with a clay core. The finished dam is 30m high and 300m wide at the top. The player takes the part of the contractor's project manager and is responsible for the planning, resource selection and use, the control and the reporting to the company management. Resources are required to excavate, transport and place the rock and clay and to maintain the haul roads.

The information for the project must be complete in all relevant detail, sufficient to create the appearance of reality but not too complex to cloud the teaching objectives. If the project does not appear ‘real’ to the player (the verisimilitude) then the desired learning outcomes will be jeopardised.

The development of the data for a new project is almost as large a task as the development of the game itself because it is, to a large extent, the project which gives the game its character and which ensures that the game can fulfil the objectives set for it.

3.2 Structure and Main Features of the Game

There are two roles in this game, the game umpire and the player.

The game umpire sets up the game and acts as the contractor’s head office whilst the player takes the role of the project manager for the contractor. The project is for all the earthmoving needed for dam construction and the contractor has to provide all resources (equipment) necessary. The player is made responsible for the performance of the project and reports to the umpire, in the role of head office, as and when specified.

The resources to be managed are those required to carry out the work of excavation, transport and placing of the rock and the clay. The site is affected by the weather, particularly the rainfall, and the resources are subject to breakdowns.

Costs are incurred by the contractor for the resources employed and for overheads. There are also liquidated damages payments for exceeding the 40-week allowed duration. Payment is made based on completed work. Retention of 10% is made on all payments. The contractor estimates costs per cubic metre of material and plans both the physical and financial progress of the project.

Since the umpire can vary all external variables (rainfall patterns, breakdown rates etc.) the project can be made to behave very differently for players of different levels of experience.

3.3 The User Interface

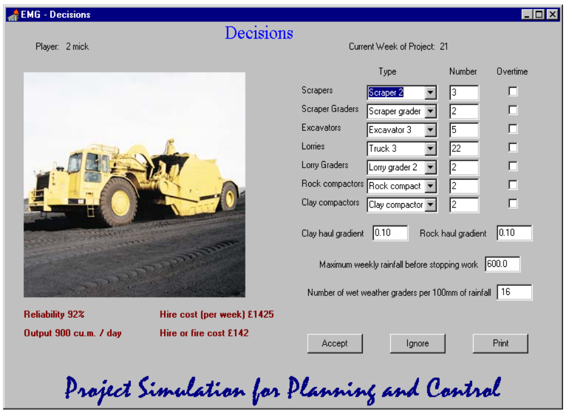

Figure 2: Screen for the selection of equipment

Figure 3: Player performance graph

The interface was designed to make use of the computer power and to develop and maintain the players’ motivation and to present the players with reports which might be expected on a real project.

A player can either choose to work by selecting the buttons or by clicking on a relevant part of the screen. A typical screen for the selection of equipment is shown in figure 2.

There is considerable assistance and information available to the player within the game, like average rain patterns, specific information on available equipment etc.

3.4 The Umpire

Throughout game play the teacher/umpire can monitor players' progress using a specifically designed IT package. This allows the umpire to check the progress and performance players throughout the simulation exercise using recorded player input, performance records and messages. The information can be used to explain developments to students, be a basis for discussion of methods and techniques of planning, monitoring or control, allow the umpire to identify struggling players or to compare the performance of players. Custom graph specification allows the umpire to define type and content of graphs. Figure 3 is an example of the output.

It is essential for the game supervisor to have a means of measuring the performance of the players throughout the simulation. Not only does this facilitate learning and discussion, it also provides evidence of the learning effects of the game. However this information service to the umpire must be carefully constructed so as not to destroy the operating environment (verisimilitude) for the game players

The more the game supervisor can monitor the play environment the greater the opportunity to exploit the players' performance to reinforce the student/engineer learning.

3.5 Monitoring and Communication within the Dam Game

In addition to their use of the games at the weekly clinic sessions, students are able to play the games at any time. In order to ensure that students are able to raise any significant learning issues or technical issues regarding the simulation games it is crucial that students can communicate effectively with teaching staff.

It is also important for staff to be able to reply easily to the students and be able to message all students in-game with any important announcements or changes to the games or the simulated project data. Both of these facilities are provided by the umpire's IT based package.

4. Incorporating IT in Simulation Games for Construction Management

Key points for development of IT based simulation games for construction management

- Learning objectives of the module must be established first.
- Chose a scenario that is suited to these outcomes and that can be simulated with a high degree of realism (verisimilitude).
- Craft the package optimizing the IT support. Balance reality with complexity. It must allow monitoring of student performance and their leaning while at the same time maintaining the verisimilitude of the exercise.
- Develop the software such that it allows monitoring of students' achievement of the learning objectives.
- Check effectiveness of the package when used in an appropriate learning environment and be prepared to change.

Simulation is a very useful tool if used in a way that recreates a realistic environment in which models complex management situations. Such is the level of complexity of the construction industry that this is best done by incorporating IT support that allows the users of the simulation to achieve appropriate learning outcomes.

5. Evaluating the Success of Simulation as a Learning Tool

Several methods (observations, student achievement of assessment tasks, and student questionnaires) were used during the evaluation process to gather information about the effectiveness of simulations in developing students' knowledge and professional practices.

Students' learning outcomes from simulation exercises were tightly linked to the generic skill statements for their overall engineering course, these included:

- demonstrating and articulating an understanding of professional engineering, its structure, workings and relationships with society;
- applying scientific/mathematical and technical theory to engineering problems;
- identifying, defining and providing solutions to engineering problems;
- producing engineering style reports;
- using engineering judgement in both quantification and elementary modelling;
- structuring engineering problems into a sequence comprising identification, formulation, solution and impact;
- demonstrating a range of effective engineering communication skills;
- collaborating effectively in, and identifying the working-benefits of, a multidisciplinary and multi-cultural teams; and
- showing an appreciation of the role and responsibilities of professional engineers
- experiencing the complexity of a project, not all situations can be planned for beforehand and random events can greatly change the project outcome

6. Major Teaching and Learning Implications of using Simulation

Students working with the simulation

It has become clear that the simulation does not replace the teaching of essential information required for project management; it is a learning tool which must be used in conjunction with formative and iterative teaching strategies. Once students can master the mechanics of engaging in the simulation, their learning from the simulation will be heightened.

Students working with uncertainty and making informed judgements

Working with large amounts of uncertain and often unreliable data such as is the case in real engineering situations was a challenge to many students. This issue also is tied to providing more information to students about how to move from theories learnt using problem specific accurate data (e.g. cost calculations) to the way in which they will have to apply these theories in real world complex multi-variable situations.

Students working in groups

The simulation evaluation clearly demonstrated that often students had little prior experience in working in groups as part of a learning experience. They were still keen to know about their individual performance within their group. This can be accommodated without prejudicing the important attribute of being able to work in and for a team.

Development of professional attitudes and attributes

One of the most challenging parts aspects of this type of learning experience is for the students to translate their learnt skills from the specific environment into general strategies and approaches that they can apply and develop when they next encounter them in the real wider world of engineering e.g. how do they develop what they have learnt about team work, project control, strategies to control production etc. Forcing them to report to 'head office' (orally and in writing) and make recommendations makes them reflect on and articulate their learning.

Reviewing students' understanding and attitudes to the targeted generic skills before, during and after using the simulation demonstrates to them and their teachers how well the simulation is achieving the learning objectives.

7. The Success of Simulation as a Learning Tool for Engineers

Simulation exercises have been used by the authors to develop professional engineering skills in a wide range of countries and teaching environments. Evaluation of learning outcomes is essential. Methods used can be any that allow objective evaluation of the extent to which the learning outcomes have been achieved.

The success of simulation in achieving targeted learning outcomes has been assessed using a variety of methods. These indicate that a higher achievement of management orientated learning outcomes have been achieved than is possible using conventional teaching methods.

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