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All the full length papers included in the Proceedings of International Conference on Engineering Education and Research, 21-24 November 2016 have been independently peer reviewed. Initially, the submitted abstracts were reviewed by the Technical Committee, and if the abstract was accepted, the authors were invited to submit full papers. The full papers were then reviewed, and the review comments were sent to the authors to address the comments in updating their papers. The revised papers submitted by the authors were then checked by the Editors, and accepted once the papers had satisfied the requirements and standards of the International Conference on Engineering Education and Research.

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Welcome by Conference Chair

On behalf of the Organising Committee, it is my pleasure to welcome you to Sydney and to the International Conference on Engineering Education & Research (iCEER2016).

The iCEER2016 is hosted by the School of Computing, Engineering and Mathematics (SCEM) of Western Sydney University, and is being supported by International Network for Engineering Education and Research (iNEER), USA. The main themes of iCEER2016 include Technology in Engineering Education, Engineering Education Delivery and Development, Engineering Curriculum Development, Collaboration with Industry, Occupational Health & Safety Education and Engineering Education, Technology & Society. The goal of the conference is to provide a platform to academics, scholars, researchers and practitioners across all continents and countries to present and disseminate the latest innovative ideas, research results, and findings on various aspects of engineering education.

On behalf of the organising committee, I wish to thank all authors for their papers and contributions to this conference. I thank Western Sydney University management for providing the facilities and infrastructure that made the organisation of this conference possible. I would like to thank the keynote speakers for sharing their wealth of experiences and knowledge in engineering education.

I would like to share with you our gratitude towards all members of the organising committee for their efforts and dedication to the success of iCEER2016. I offer SPECIAL thanks to the General Co-Chair Dr Vojislav Ilic for his excellent contribution, members of the International Technical Committee and other reviewers, who offered their time and technical expertise in the review process. I also thank Professor Simeon Simoff, Dean, School of Computing, Engineering and Mathematics, Western Sydney University for his excellent support in organising this conference. I would also like to thank iNEER for their cooperation and support (especially Professor Dr Win Aung) and SCEM Event & Marketing staff, in particular, Ms Nicolle Fowler, for providing secretarial and logistic support, which is the heart of ICEER2016. Special thanks to all Session Chairs, Student Volunteers and Sponsors for their contributions to make iCEER2016 a success.

Finally I would like to thank all speakers, participants and attendees. I look forward to several days of stimulating presentations, debates, friendly interactions and thoughtful discussions that will forward engineering education.

Associate Professor Ataur Rahman, PhD, FIE Aust.
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Western Sydney University, Australia

iNEER Welcome

As a member of the iNEER Board and on its behalf, it is my pleasure to welcome you to the 2016 iNEER event hosted by the Western Sydney University School of Computing, Engineering and Mathematics. This is the second iNEER conference in Australia; the first was in distant 2007 at the Victoria University in Melbourne.

In its striving for excellence in all its fields of endeavour, the Western Sydney University, graciously offered its hospitality in 2016 to the iNEER International Community through the School of Computing, Engineering and Mathematics, headed by the Dean, Professor Simeon Simoff. iNEER formally thanks everyone who made this event possible.

iNEER had its beginnings in the early days of globalization by providing an effective professional platform for collaboration, exchange of ideas and collegiality between international communities engaged in education of future engineers. This was especially welcome in times of lingering international isolation, as was the case immediately after the Cold War Era. This platform had no membership fees and relied entirely on participants' strong motivation to share their professional experiences and provide excellent opportunities for international liaisons world-wide. It proved a huge success, largely thanks to its hard working Secretary General, Dr Win Aung and like-minded close collaborators who all shared the same vision and passion! It held meetings/retreats amongst scholars in various countries. I was privileged to join it when it formally became the International Network for Engineering Education and Research (iNEER) in 2001, having discovered its earlier morph in the year of Sydney Olympics, and have participated in most of its events ever since!

In its quest to promote exchange of ideas amongst engineering educators, iNEER also published a highly successful annual compendium of innovative ideas entitled World Innovations in Engineering Education and Research with contributing authors from different parts of the globe. In addition, it awarded formal recognition for exceptional educational endeavours of individual members at its annual events. In this way, iNEER set high standards for the conferences of this type that have since emerged.

On behalf of the iNEER Chair, Professor Frode Eika Sandnes, Pro Rector, Oslo and Akershus University College of Applied Sciences Oslo, Norway, I welcome you all to the iCEER 2016!

Vojislav Ilic, PhD
Member
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We wish to thank and acknowledge the following Sponsors for their contribution towards this conference.

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Engineering Education in Bangladesh: Implementation of Online Delivery Approach

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Abstract: Delivery of university education is rapidly changing across the developed countries due to wider adoption of e-technology. However, most of the developing nations are not keeping up-to-date with the new education delivery systems such as blended learning and flipped class room approaches. This paper reviews the engineering education delivery systems in Bangladesh at both public and private universities. It has been found that Bangladesh uses traditional "chalk and talk" approach in delivering engineering education in most of the public universities; however, private universities are using some of the modern e-technologies to deliver engineering courses. This paper also discusses how online delivery of engineering courses can possibly be implemented in Bangladesh. In this regard, the model of Bangladesh Open University and cheaper mobile phone technology can be useful.

Keywords: Engineering education, Bangladesh, online courses, Open University.

1. Introduction

The need for changing engineering workforce that is becoming more computer-oriented than twenty years ago warrants a shift from the traditional lecture–example–homework format of course delivery to more learner-centered approach. The traditional 'chalk and talk" approach is being phased away rapidly from the university education systems in developed countries. In this regard, a number of new education delivery methods are becoming popular in the developed countries. The use of learning management systems (e.g. Proprietary Blackboard and open-source Moodle Software) has been playing a major role in these new education delivery methods (Martin, 2012). For example, flipped class room approach is being emerged as an effective method where lectures and tutorials are pre-recorded for students to listen before coming to the classes so that the class time can be used for active learning.

Massive online courses (MOOCs) are attracting millions of students in a course at little/no cost. The shift toward MOOCs is growing as more and more "players" have been entering into this market, which could put the traditional course offering by many universities in danger since MOOCs can be accessed by anybody in the world living anywhere having a fast internet access at a very low price. As an example, one course offered by a Stanford Faculty in 2011 received 160,000 students; about 23,000 of these students completed this 10-week course (Lewin, 2012).

Another method is becoming popular, known as blended learning approach, where the best aspects of face-to-face and online deliveries are utilised to enhance learning experiences of the students. For example, Rahman (2016) showed that teaching and learning of fluid mechanics for civil and mechanical engineering students by a blended learning approach at the University of Western Sydney enhanced the learning experiences of the enrolled students. In this adopted blended learning approach, online recorded lectures, online recorded tutorials, hand written tutorial solutions, discussion board and online practice quizzes were made available to students via vUWS system (online method) and the face-to-face lectures were used to provide more interactive discussion to enhance students' learning.

This paper presents an overview of engineering education delivery in Bangladesh, a country with over 160 million populations, with a lower middle income level (per year per capita income of US$ 1,466). This explores how some of the new education delivery systems can be adopted to Bangladesh to train the new generation engineering students. This is in line with the current Bangladesh Government's vision to build a digital Bangladesh.

2. Overview of Engineering Education in Bangladesh

The engineering education in Bangladesh started in 1876 with the establishment of the then Survey School of Dhaka by the British Raj. In 1908, it was upgraded to Ahsanullah School of Engineering with the provision of technician level education (diploma engineering) and further upgraded to a collage by offering degree courses in Civil, Electrical, and Mechanical Engineering disciplines after the creation of East Pakistan in 1947. The initial intake capacity of 120 students in the college was increased to 240 students in 1960. With a view to organize and develop both the undergraduate program and introduction of post graduate study and research to meet the requirement of economic developments in the country, the Ahsanullah Engineering College was upgraded to the status of University (named Bangladesh University of Engineering and Technology (BUET) on the 1st of June, 1962 by the East Pakistan Government through promulgation of an ordinance.

To meet the growing demands for engineers and to provide higher educational facilities at different parts of Bangladesh, many new engineering and technical universities have been established in Bangladesh since 1962. Five of these are dedicated to engineering courses only i.e. RUET, CUET, KUET and DUET. Table 1 provides a list of all public Engineering, Science and Technology Universities in Bangladesh. As mentioned by Chowdhury and Alam (2012) there are about 7,000 yearly intakes of engineering students in Bangladesh i.e. 44 engineering students per million people, which are 1344 and 214 engineering students per million people for South Korea and India, respectively.

In Bangladesh, three main types of universities (public, private and international) are providing tertiary education service to the students. There are 29 public, over 54 private and 2 international universities in Bangladesh (Chowdhury et al. 2008). Besides the degree awarding universities, there are numbers of colleges affiliated to the National University (NU) of Bangladesh. Most of these colleges offer Bachelor of Arts (BA) course at the tertiary level. At present, numbers of NU affiliated colleges are around 1,400. At the time of independence of Bangladesh in 1971, only 4 public universities were serving a population of about 70 million.

The private universities started growing since 1992, when the Private University Act by the nation's parliament was adopted. Since then the country has experienced a spectacular growth in private universities. Nevertheless, access to tertiary level education is still very poor in Bangladesh; only about 12% of the high school finisher (i.e. year 12 graduates) can enter into higher education due to limited intake capacity of universities in Bangladesh. Moreover, more than 80% of these 12% students are in the NU affiliated colleges, the remaining are fortunate enough to be in the public and private universities. This is due to limited number of seats available in the universities. In a statistics of 2008 presented by Chowdhury et al. (2008), it was found that only about 6,000 students get the opportunity to be admitted into engineering universities in Bangladesh from a population of over 150 million.

Table1 List of Public Engineering Universities in Bangladesh

University	Acronym	Established	Location
Bangladesh University of Engineering and Technology	BUET	1962	Dhaka
Shahjalal University of Science and Technology	SUST	1986	Sylhet
Hajee Mohammad Danesh Science and Technology University	HSTU	1999	Dinajpur
Mawlana Bhashani Science and Technology University	MBSTU	1999	Tangail
Patuakhali Science and Technology University	PSTU	2000	Patuwakhali
Dhaka University of Engineering and Technology	DUET	2003	Gazipur
Rajsahi University of Engineering and Technology	RUET	2003	Rajsahi
Chittagong University of Engineering and Technology	CHUET	2003	Chittagong
Khulna University of Engineering and Technology	KUET	2003	Khulna
Noakhali Science and Technology University	NSTU	2008	Noakhali
Jessore University of Science and Technology	JSTU	2008	Jessore
Pabna University of Science and Technology	PSTU	2008	Pabna
Bangladesh University of Textile	BuTex	2010	Dhaka
Bangabandhu Sheikh Mujibur Rahman Science and Technology University	BSMRSTU	2011	Gopalganj
Bangabandhu Sheikh Mujibur Rahman Maritime University	BSMRMU	2014	Chittagong
Rangamati Science and Technology University	RMSTU	2014	Chittagong

Among all of the engineering universities in Bangladesh, BUET is the most reputed one. Its predecessor was known as Ahsanullah Engineering College; the academic programs of this college were based on the British undergraduate curriculum (Rashid, 1958). Engineering curriculum went through notable changes in 1953 through a linkage program with the Texas Agriculture and Mechanical College (presently known as Texas A & M University) (Rahman and Haseeb, 2007). Since then, BUET has maintained its academic relationship with many foreign universities through different linkage programs. All the engineering universities in Bangladesh are providing major engineering courses. For example, BUET provides eleven branches of engineering degrees to the students: Civil Engineering; Mechanical Engineering; Chemical Engineering; Water Resources Engineering; Material and Metallurgical Engineering; Naval Architect and Marine Engineering; Industrial and Production Engineering; Electrical and Electronic Engineering; Computer Science and Engineering; Biomedical Engineering; and Glass and Ceramic Engineering.

Current mode of teaching in engineering universities in Bangladesh is "class-room based/teacher-centred" where students get their lessons face to face during the lectures and tutorial classes. Laboratory classes are also conducted via face-to-face where students do experiments under the supervision of the lab teachers. At current situation, no online or blended learning (i.e. mixture of face to face and online) has been implemented by the public engineering universities in Bangladesh. In addition, use of computers/projectors in classroom in still limited. Only few teachers have adopted the PowerPoint presentation along with black/whiteboard teaching in the class room, most of them are still following "chalk and talk" approach of teaching. Evaluation of the students is based only a few traditional written examinations (e.g. class tests, assignments and final examination). Industry-university relationships are also not significant for most of the universities.

In Bangladesh, most of the teachers follow deductive approach (i.e. teacher-centred) in teaching; they deliver and explain the concepts and then expect students to complete tasks to practice the concepts. But in general view from student's perspective, it should be inductive approach in teaching. Fortunately, engineering universities in Bangladesh are blessed with top students as the admission process is highly competitive. For example, in general 9,000 candidates are normally selected to allow for admission test in BUET, with about 900 intakes (i.e. 10% success rate). With the current engineering education system in Bangladesh and face to face learning, the institutions are producing some good graduates, who do well locally and globally (Islam, 2012).

There is relatively a better approach of engineering course delivery in some private universities such as the North South University (NSU), which was established as the first private university of Bangladesh in 1992. The engineering education of NSU is run by its School of Engineering and Physical Sciences, which comprises four departments including Electrical and Computer Engineering, Civil and Environmental Engineering, Architecture and Mathematics and Physics. All faculty members of NSU are graduates from reputed universities worldwide, especially from USA, Canada, UK, Japan and Australia. The highly trained faculty members have moved away from the 'chalk and talk approach'; rather they use e-technologies (such as power points, on-line journals, and video clips) and practice the 'learning by doing' approach in their classrooms. The Engineering School of NSU has also incorporated many positive additions and modifications in response to the continued changes in national and global technological demands and needs of the industries (NSU 2016). Students can download the Power point lecture notes and other learning materials from the "Resource Drive" through their university server. NSU has also established on-line teaching evaluation systems and provides fully-automated on-line based library services. These technological developments in the academic learning system promise the potential to introduce on-line based courses for engineering education.

The Australian universities are far advanced than Bangladesh in providing learning materials via online facility such as ‘vUWS” in Western Sydney University. Bangladesh is yet to catch up in this regard where the capability of the current mobile and internet facilities are under-utilized in public university systems. This may push back Bangladeshi students in the international arena where they have to compete with many emerging nations like India and China who are moving at a much faster rate in engineering education delivery by using latest e-technology.

3. Upgrading Engineering Education delivery method in Bangladesh

There are scopes to improve the course delivery methods in Bangladesh to improve the quality of graduates from engineering universities by up taking recent developments in engineering education delivery. One of the important concepts to be implemented is ‘blended learning’ in engineering education in Bangladesh. It has been proven in many universities in the developed counties that the blended learning approach produces better learning outcomes for the students. There are other benefits in adopting a blended learning approach in Bangladesh, such as:

1. To make the engineering education available to the remote/rural areas, as the vast majority of the people live below poverty line and are unable to attend the urban based institutions despite they have the required capability/potential to undertake engineering studies.
2. To make the engineering education available (as a part-time student) to the students while they are working. In the current situation, students cannot avail the engineering education especially in public universities if they are not full time students.
3. If a student misses a face-to-face lecture, he/she struggles to get the concept presented in the lecture as there is no recorded lecture available to students.
4. To increase the flexibility of the course i.e. to access the lectures and tutorials online sources via pre-recording the lectures and tutorials where students can listen to the lectures/tutorials at their convenient time, and as many times as needed.
5. The diploma engineers who want to upgrade their qualifications can find online/blended delivery quite useful as they can study while working.

6. Online delivery of tertiary education in Bangladesh

In Bangladesh, engineering courses have traditionally been delivered face-to-face (FTF) for many years. In many developing countries, the traditional mode of delivering engineering course is still being practiced. However, in keeping pace with the rapid development of technology and its wider incorporation in education delivery method in the last three decades, engineering courses are now being offered through a variety of different eTools (Bourne et al., 2005). In line with the developed nations, many developing countries have now been offering online degrees in some universities and colleges, mainly in non-engineering fields, and many others are in the process of adopting the same. Online engineering programs have become increasingly popular in the USA in last decade due to the advantages of widespread utilisation of modern technologies that overcome the fundamental barriers of online/distance education delivery. The growth rate of online higher education in the USA is disproportionately higher than conventional higher education. Allan and Seaman (2007) reported online enrolment in the United States increased by more than 20% a year between 2002 and 2006, which is about six times greater than enrolment growth in on-campus classes. Studies also reveal that online engineering program is as effective as on-campus models, if not better (Cook et al., 2008).

Although, online delivery and its proven effectiveness in delivering non-technical subjects have been established in the education sector long back, online teaching, in general, presents many challenges. Teaching and learning engineering online present additional challenges unique to programs with highly technical contents. There are two major concerns in delivering engineering programs through an online learning model: (a) how to deliver effectively the technical contents at distance and (b) how to use laboratories as part of online courses. In addition, there are other common constraints involved in online education: (a) enrolment and payment methods (b) quality of learning outcomes (c) need for appropriate instructors available for student access and (d) security and authenticity.

Despite of a wider acceptance of online education concept in developing countries the adoption rate is still not very significant (Bélangera and Liu, 2008). Evidences of online technical education, especially engineering courses in developing countries are rare. While eLearning has become a norm in the United States, it has just reached adolescence in the Pacific due to academic isolation, struggling economies, and limited technology (Heine, 2007). Online approach of delivering engineering courses in Bangladesh is “nil” till to-date. The fundamental reason that Bangladesh and similar developing countries are lagging behind in the race of online education is the lack of infrastructures facilities. In Bangladesh, most of the public universities including, engineering universities are located in the urban area. This tendency of being centralized is mainly due to availability of the infrastructure facilities offered only by the urban areas in Bangladesh. Students from rural population have to incur a huge living cost and face tremendous relocation difficulties to attend an on-campus program. On the other hand, these urban-based tertiary education facilities exert extensive socio-economic pressures on urban lifestyle as well. Some of the common problems are increased population density, inadequate transportation facilities and limited access to basic citizen facilities. In addition, continuous political unrest is one of the leading causes of session congestions in most public and private universities in Bangladesh that has constipated the whole education process. With the same token it is also observed that the teaching focus in Bangladesh was more based on face to face and very less emphasis was given on assignments, use of computer programming, project work and critical writing.

However, it is inspiring that a remarkable development has been occurred in Bangladesh in the last decade in educational infrastructure and telecommunication industries. Digital Bangladesh, the manifesto of present government is a mile stone. The cascading effect of digitalization inspired educators to put away “the chalk and pick up mouse” for delivering education online. One such visible and vibrant example is Bangladesh Open University (BOU), which has said “no” to the traditional chalk and talk approach. BOU is the only university in Bangladesh that offers 100% online and distance education in both undergraduate and postgraduate levels in Business Administration in addition to other humanities subjects. BOU is designed with state of the art technology and fully equipped with most modern technological devices like silicon graphics, digital editing suites, electronic preview theatres, microwave communication link and full-fledged audio-video studios. BOU also produces its course materials and runs its tutorial services by both print media and electronic media. The print media includes books, readers guidebooks, journals, students handbook etc. The learners of all academic programs of BOU are provided with a complete set of textbooks written in modular form. BOU operates 12 Regional Centres (Campuses), 80 Sub-regional Centres, 1451 Study Centres and 1194 Examination Centres through the country. It has 4,99,936 enrolled students (session 2013-2014) and 24,755 teachers/tutors. BOU is currently in progress of developing an E-learning Centre and Interactive Virtual Class Room in collaboration with Korean International Cooperation Agency. This will increase the capacity of the university to deliver technical courses through an online module.

7. Potential for online delivery of engineering courses in Bangladesh

It is apparent from above discussion that there is growing need and potential market existing for online engineering program in Bangladesh. By the same token it is worth to visualise the demand of an online or distance engineering program. Considering both the opportunities and the challenges, BOU aims to incorporate a delivery module for online engineering program in future. Research has been in progress to develop a conceptual model which will offer online engineering courses with Blended Learning Approach. This program will initially offer bachelor and masters degrees in three subjects, Civil Engineering, Telecommunication and Computer Engineering. Bangladesh Open University (BOU), the host university may operate the program either in individual capacity and or in collaboration with public and private engineering universities as well, through a resources sharing mechanism. Curriculum will be designed in accordance with adequate incorporation of humanities and management subjects relevant with the context of industry requirements. For the purpose of practical demonstration of technical contents a virtual laboratory would be utilised. Onsite internships and shorter duration work-camp will be arranged with different industries to facilitate hands on experience for the graduates. This will assist to close the gap of the number of engineers per million people with India and other regional countries.

8. Conclusion

This paper presents an overview of engineering education delivery methods in Bangladesh. It has been found that Bangladesh has lagged behind in engineering course upgrade compared with developed nations. It has been found that Bangladesh is still uses traditional “chalk and talk” approach in delivering engineering education in most of the public universities; however, private universities are using some of the modern e-technologies to deliver engineering courses. Bangladesh is yet to catch up in this regard where the capability of the current mobile and internet facilities are under-utilized in public university education delivery systems. This may push back Bangladeshi students in the international arena where they have to compete with many emerging nations like India and China who are moving at a much faster rate in engineering education delivery using latest e-technology.

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Content Analysis of Australian Design Jobs to Improve Curriculum

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Abstract: This paper reports the key knowledge and skills sought for industrial design jobs in Australia. Our goal was to find out the required skills and what attributes of the jobs are highly desirable and what levels of proficiency are required for a particular job. We have collected online job advertisements from seek.com.au. In total 60 job advertisements were identified, which were later used for content analysis. Our result shows that some job titles (n = 18) were used synonymously such as industrial designer, product design engineer and mechanical engineer. In our analysis we have identified key skills for the design jobs and we have observed that in addition to domain specific skills majority of the jobs require very high proficiency in software tools for example SolidWorks or CAD. Finally, we outline the key implications of our findings for design students and educators to update their curriculum.

Keywords: Content analysis, design education, curriculum development

1. Introduction

Industrial design is an important and integrated profession. Its area covers a wide range of specialties such as engineering, business, ergonomics and aesthetics. Furthermore, it includes social, environmental, and cultural issues (Giard, 2000; ICSID, 2003; IDSA, 2003). Product designers focus on people's needs and on how to create safe and usable products that can be adjusted to the varying lifestyles of people. Thus, product designers or industrial designers, emphasize the way in which people live, deal with concepts, appearance, performance and human factors that play a key role to influence design. On the other hand, engineers, focus on details, functionality, performance and production, and tend to concentrate more on the problems of making a product function better for the tasks it is designed to do while optimizing its design for production (Owen 2004). The field of industrial design optimizes function, value, and appearance of products and systems for the mutual benefit of users and manufacturers. Therefore, the industrial design profession extends to include not only the categories of engineer, commerce, and aesthetics, but also to concern with social and cultural issues of design.

From a general perspective there seems to be a gap between what is taught in design schools, and what design industries are looking for. There are several notions about design education regarding the approach and focus of their education, which also depends on the design school. As design education seems reluctant to move beyond basic aesthetics and form giving, the balance between theory and practice has become a crucial issue for curriculum development in this discipline (Kolko 2004). Incorporating practice into design education is also an important part of the interrelations with industry. Although various applications concerning relations with industry in education (Boyarski 1998) have been widely discussed in the literature, the problem remains one of the fundamental issues in design education. A primary concern of design educators and professionals is the issue of the competencies of industrial designers, and the quality of the graduate is often considered by prospective employers to be subpar (Kaufmann 1998). Consequently, there exists a gap between what students learn at design schools and what they are required to do in the professional field after graduation (Ball, 2002; Yeh, 2003; Yang et al., 2005).

Methods to educate or train designers differ across different countries and design schools. Some design schools provide generalist-oriented programs to educate designers and some other programs provide training people from multiple disciplines in a specialised manner. From our experience we would like to stress that the method of education would depend on the policy of the institution. However, the most important requirements are the quality of designers as produced by the quality design education and the competencies of the designers for industries. Furthermore, the multidisciplinary approach of design education and close collaboration with industries and research institutions will produce future competent designers who will lead the industries. Above all, the competencies of industrial designers are very important to find a suitable job after finishing their tertiary education.

The notion of design and the employment opportunities of designers have become more important as new concepts continue to be introduced day by day. During the product development process, the key tasks are planning, designing, prototyping, and engineering. The successful completion of each of these tasks depends on certain skills such as planning, understanding users, ideation, creativity, sketching and drawing, as well as model making, abilities to making sophisticated prototypes for appearance models, operating models, mechanism models, etc. (Chang, 1995). These attributes are definitely the key competencies of industrial design jobs. These competencies also vary depending on the job responsibilities and different levels of proficiencies, which are required for different job.

There are some prior research studies in this domain for example the work of Yea (2001), Yang, et al (2004), and Ramirez (2012). The work of Yea (2001) focused on Taiwan where as the work of Yang et al. (2004) focused on Chinese job markets. The study conducted by Ramirez (2012) focused on employability factors for industrial design graduates and in US job markets. Those studies figured out the key competencies required for industrial design jobs however, none of those studies focused on the proficiency and required level for industrial design jobs. It is very important to achieve certain level of proficiency in certain areas. The study reported in our paper investigates the level of proficiency required for industrial designers as sought in job advertisements. This study aims to understand the various job titles currently adopted in the industrial design profession in Australia and help design educators to guide industrial design students to plan their careers ahead.

2. Method

We have adopted descriptive research design for data collection and data analysis to formulate accurate descriptions and verifications of job advertisements. Job advertisements available from the Australian job site seek.com.au were retrieved over three months. Content analysis was conducted to analyse the competency levels required for each job. We have done a key word search to extract relevant jobs. The keywords were industrial design, product design, industrial design engineering and product design engineering. The collected data were assembled in an Excel sheet to apply the content analysis procedure.

3. Results

Below we present the key results based on the content analysis of the job advertisements.

3.1 Job titles

We have observed several job titles, which were used synonymously for industrial designers. Out of 60 job titles, 18 had titles (see Table 1) where the job was for a mechanical or industrial designer. Furthermore, some jobs were for entry level such as graduate design engineer/design internship, some were for more advanced level such as design manager/senior design manager/project manager engineer. Furthermore, the terms designer and engineers were used interchangeably. Sometimes job titles were misleading for example, the job title 'design consultant' usually showed several years of experience which in not clearly understandable from the title. We have found the following 4 jobs, which were clearly identifiable from the job titles as entry-level jobs:

Table 1 The 18 job titles where the word mechanical or industrial designer or engineer was used synonymously

Mechanical /Industrial design engineer
Junior Industrial/ packaging design opportunity
Graduate industrial designer/product design engineer
Mechanical/Industrial Design engineer
Industrial designer/product design engineer
Product design engineer/Industrial engineer
Industrial/Graphic designer
Mechanical designer/Industrial designer
Brand manager-industrial designer/engineer
Mechanical/product designer –Lighting/Electronics
Senior mechanical engineer/Electronics products designer
Industrial designer/Product design engineer
Industrial/ Graphic designer
Mechanical/product design engineer-lighting/electronics
Design Engineer/Industrial Designer
Industrial designer/Product design engineer
Mechanical drafting/Industrial Designer
Mechanical/ industrial designer

- Graduate industrial design engineer/product design engineer
- Graphic design intern
- Junior industrial designer
- Industrial designer internship

There were other jobs (n=12), which were also suitable for new Industrial Design graduates however those were not identifiable from the job titles, as those titles did not have the word intern or graduate.

We have found the following jobs (n=6), which were identified, as senior level position:

- Design manager
- Brand manager: industrial designer/engineer
- Senior design manager
- Senior design architect
- Regional design manager
- Experienced industrial designer

3.2 Required Competencies Mentioned in Job Advertisements

Generally the job advertisements were classified into several parts such as tertiary qualification, work experience (i.e., prior work experience, currently working or not) and toolset experience. Other skills such as report writing skills, communication ability were sought in each of the job advertisements. Furthermore, there were domain/job specific requirements. Last but not least requirement written on the most job advertisements was portfolio. Below we describe the commonalities and differences observed in those job advertisements by analysing the required level of skills.

3.2.1 Qualification

Most of the advertised jobs asked for tertiary qualification or equivalent in Industrial Design or Product Design/engineering obtained from local universities or abroad. We have observed that several keywords such as recognized degree, minimum degree level qualification have been used to determine the tertiary qualification. For graduate industrial designer, the end result from tertiary qualification was also given preference for example, distinction or honours from a reputable university. Most of the other jobs (n = 45) just mentioned tertiary qualification or degree level qualification and did not ask any other attributes to quantify it. In those jobs tertiary qualification was considered a priority in conjunction with other key skills and experience. For the position of a Design Manager job, strong design management background was sought.

3.2.2 Work Experience

The required work experience varied across job titles. All jobs asked for recent work experience except for the graduate jobs or internship position. For example, a graduate product or industrial designer asked candidates who graduated in the last two years could apply. Other jobs asked for 1 to 8 years of job experience where the minimum number of years of experience is articulated by writing the word ‘minimum’ or ‘at least’ which clearly indicted the strength given to candidates having the right amount of work experience. Consultant jobs or jobs which are considered for experienced people or managerial position require at least 5 years of experience in the similar role. For Industrial Design jobs on average 2 years of work experience was sought.

We have also observed that some jobs asked for continuous experience by mentioning ‘preferably continuous and current/ relatively recent experience’. In order to strengthen the requirement the words must or preferably have been used. For example, a job advertisement for Industrial Designer mentioned demonstrable design experience must either be currently working or have within the past six months been working on similar position.

3.2.3 Experience with Software Tools

The levels of competencies were defined in various ways. Several adjectives/keywords were used to define different levels of competencies such as good proficiency, high proficiency etc. SolidWorks, CAD and Adobe suits are three top three skills, which were advertised for the jobs. Some jobs looked for a software tool experience, which was mandatory while other job advertisements were looking for tool set experience just as high proficiency or good proficiency in SolidWorks or CAD. We have found that there are different levels of expertise required in different job profiles.

Table 2 Experience and required level of proficiency for software tools

Software tools	Level of proficiency	Required
Solidworks, CAD, CorelDRAW, SketchUp, Autodesk Inventor, Adobe Photoshop, Illustrator, InDesign, MS excel, MS Word, 3D rendering package (V-Ray, 3DS Max), Photoshop rendering	High proficiency, experience using a particular software, skilled, excellent knowledge, substantial experience, competent, advanced knowledge, excellent proficiency, intermediate skills, competent, capable, strong, extensive	Mandatory, must have, perquisite, should have, highly desirable, essential, beneficial, desirable, required

3.2.4 Other Skills

In total 14 other skills were identified such as communication ability, taking initiative, ability to work independently and in a group, report writing, detailing, problem solving, time management, work ethics, attitude, analytical ability, multitasking and organizational skills, managing capabilities (i.e., conduct and coordinate) and networking capability. Those skills were considered mandatory in addition to tertiary qualification and toolset experience. Table 3 shows the key skills extracted from the job advertisements.

Table 3 Skills required for the collected jobs

Other skills	
Communication ability: clearly, accurately, concisely, outstanding, excellent, fluent *'Must have'*	-Must be able to communicate technical issues and ideas accurately, clearly and concisely -Ability to accurately, clearly and concisely communicate technical issues and ideas both verbally and in written form -Clear communication skills -Outstanding oral, written and visual communication -Excellent communication skills -Communicate clearly -Fluency in English
Self initiation: natural ability, inbuilt drive *'Must possess'*	-Must possess a natural ability to use initiative to drive developments to their conclusion along with an inbuilt drive to overcome obstacles and gain results. -Initiative

Independence/work independently: ability *'Essential'*	-Ability to take developments across all stages of the design cycle is essential -Ability to work unsupervised and/ or part of a team -A genuine team player -Ability to work autonomously
Report writing and presentation: experience, good, excellent *'Required'*	-Experience in the generation of production and technical documentation -Report writing -Good documentation skills-read, interpret and develop technical drawings
Detailing: strong, high, great, good, ability, exemplary *'Required'*	-A good eye for detail, with the ability to produce clean, yet beautifully designed collateral in areas of product and packaging. -An eye for detail and analytical assessment skills -Great attention for detail -Exemplary attention for detail -Strong attention to detail -High attention to detail
Problem solving *'Have'*	-Initiative in problem solving -Product problem solving -Strong problem solving skills -Creative problem solving skills -Proven problem solving skills
Time management: ability, highly, good *'Should have'*	-Good time management skills -Excellent time management -Highly organized, disciplined -Ability to work tight deadlines -Ability to work calmly under pressure
Work ethics: excellent *'Should have'*	-Excellent work ethic
Attitude: positive, open, pro-active	-Positive attitude, open minded, pro-active approach to work challenges
Analytical: highly	-Highly analytical candidate
Multitasking and organisational skills: ability, strong	-Strong Multitasking and organisational skills -Ability to multitask -Ability to manage multiple projects
Conduct and coordinate	-Conduct and coordinate onsite meetings
Decision making: ability	-Ability to take decisions
Networking: ability	-Able to interface with clients

3.2.5 Job specific requirements

Some job advertisements were more specific in terms of experience of the candidates though the basic qualifications of those jobs (n = 17) were Industrial Designer/ Mechanical Engineer/Product Designer. Almost half of the job advertisements mentioned additional job specific skills, which should be demonstrable by the job applicants. Job specific requirements were mentioned as sound knowledge, deep understanding, knowledge of, consideration for etc. For example, a job for graduate industrial design is looking for skills such as sound knowledge of injection moulding, die casting and sheet metal forming processes. Another entry-level industrial design jobs asked for knowledge on sheet metal fabrication, which would be an advantage. These requirements clearly show that domain specific knowledge is required and advantageous for the prospective candidate. However, from the job advertisements it is clear that job seekers also want to have demonstrable experience on these components.

3.2.5 Portfolio

Portfolio was mandatory for half of the jobs as it was mentioned in those jobs advertisements as a 'must provide'. Generally, a portfolio should demonstrate products and components to show design and technical ability and explanation of project involvement. Some job advertisements asked to provide hard copy of folio where as other advertisements asked to send a web link to the folio. Some of the job advertisements just asked to provide the best work such as *'a sample of your best work'* or *'copies of previous work'* or *'a strong portfolio of previous work*' while other job advertisement asked specific items. For example, portfolio should include a. modelling and rendering experience with SolidWorks, sample of work in Adobe suits, sample of engineering drawings and freehand sketching. For some industrial design jobs (n = 5), showing a physical folio was mandatory during the interview.

4. Discussion and Conclusion

Here we describe the implications of our results for students and design educators and design schools. Some of the job advertisements which we extracted from the seek.com.au website were very elaborate and some were very brief. Clearly there were some similarities and differences in the way the job advertisements were written and presented on the website. However, the extracted data and the analyses show the clear trend of required competencies, which are required for Industrial Design jobs.

The first and foremost requirement is the tertiary qualification and degree, which was, regarded the basic requirement as the primary qualification of the intended job. The second key requirement is the relevant job experience. Though for the entry-level jobs one year of experience was required which could be compensated by doing an internship in the relevant industry. Generally design schools provide opportunities to do internship during their university education. One of the striking requirements, which we observed, was the experience of software tools and other skills, which are sought for industrial design jobs.

We have observed that, technical skills such as 2D and 3D software skills are very important for industrial designers. Other researchers who conducted studies in China and Taiwan raised a similar issue (Yang et al., 2003, 2005). However, we also found out that the level of proficiency as required for those jobs are very important to consider. As evident from our results that candidates need to have high proficiency, which were regarded either as mandatory or essential for certain jobs.

The software tools (Table 2), which we identified from the job advertisements, are taught in design schools and students are required to deliver their assignments using those tools. However, our personal experience while teaching design students and evaluating their assignments show that students underestimate those tools and therefore do not realize the required proficiency level which is imperative for professional practice. The reason partly could be that the use of software tool is required to accomplish only one portion of their design assignment. That means while student do design assignments they spend a substantial amount of time for brainstorming, ideation, concept selection, and detailed designing and eventually end up with the last part of the task where they need to produce technical design by using SolidWorks and rendering by using Adobe products having little time at hand to produce quality output using those tools. On the other hand, if students have not achieved a high level of proficiency in using the software tools from a particular course dedicated to master those tools; it becomes difficult for them to show proficiency in their design assignment due to lack time and expertise. Therefore, it is advised that students should spend additional time to master those software tools.

The 14 skills, which we identified from the job advertisements, were also considered very essential for Industrial Design jobs. As evident from Table 2, most of them were required on a very high level as advertised by using keywords such as 'required, essential, should have, have, must possess etc.' Most of the other skills are practiced during a design education especially by the use of design project-based learning environment. However, it might not be possible for Industrial Design graduates to practice all those skills in one project. Again, it is important to realize for the prospective students that those skills should be achieved with high standards as most of the jobs advertisements advertised those must have skills with varying level of proficiency range from ability to exemplary skills. In addition, it would be a good idea for students to have an awareness of the attributes (Table 2) to act proactively in design assignments or industry engaged design assignments. These skills are also key to the competency centered learning approach (Hummels et al., 2011). In addition to core subjects, design school should offer specific courses for professional development of design students. It could be a separate module taught by professionals who have experience in providing personal development training. Furthermore, core design courses can be offered where design educators and personal development trainer can be engaged to help students achieving their professional skills.

Generally, job specific skills are mostly taught during a tertiary education. However, it is also related to specific current or prior job experience. Having a thorough understanding of the industrial design programs by studying and practicing it would help students to fulfil the basics of the job specific requirements. Doing internship or gaining similar industry experience will help them to achieve the remaining skills. For industrial design students it would be useful to gain deep understanding of the domain specific knowledge and able to demonstrate those in their design assignments as a demonstrable experience of this component.

Portfolio is regarded as the proof of competency of the designers. Design students generally produce portfolio for each design course they follow in order to deliver their design assignments. As observed from our results, potential job seekers should be able to create portfolio and present their best work as requested by the job advertisements. However, it is important to realize that selecting own best designs and organizing requires knowledge, as most the time it is not indicated what things are needed to be included in the folio. Based on the job advertisements our suggestion would be to demonstrate products and components to show design and technical ability and explanation of project involvement. As sometimes, employer ask for online link of the folio, it would be wise to consider to work on web folio. Our experience shows that some design schools ask students to create online folio of their semester work, which are assessed at the end of the semester. While it is a requirement for every design student to create a design folio for each course, it would be worth investigating how to make a folio for potential employer where only very best design outcomes can be shown.

After analyzing these job advertisements and going through each of these we have observed that most job advertisements looked for very high level of those attributes and the requirements were mandatory as mentioned like must have or must possess. We have identified various competency areas, level of proficiency, which were sought for industrial design jobs. The required competencies differ between various design tasks as well as between different types of design organizations. However, we found that a very high level of tool set experience was required for most of the industrial design jobs. We believe that these findings will be useful for students and design educators to update their curriculum. In the next step, we would like to compare our findings with the current industrial design curriculum of some Australian design schools.

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Individual and Social Requirement Aspects of Sustainable eLearning Systems

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Abstract: Internationalisation of the higher education has created the so-called *borderless university*, which provides better opportunities for learning and increases the human and social sustainability. eLearning systems are a special kind of software systems, developed to provide a platform for accessible teaching and learning, including also online access to learning materials and online support for learning and teaching. The aim of our current work is to extract, analyse, and combine the results from multiple studies in order to develop a requirements engineering framework for sustainable eLearning systems.

We call a system sustainable, if it has a positive effect on and whose direct and indirect negative impacts resulting from its development, deployment, and usage are minimal. Sustainability has various dimensions. We classify sustainability requirements of eLearning system to five dimensions: individual (human), social, technical, environmental, and economic. In this paper, we focus on human and social aspects (i.e., individual needs the relationship of people within society), as the eLearning systems have a very strong impact on human dimension of sustainability, where their impact on environmental dimension is rather small. This also provides us a basis to identify the corresponding requirements for sustainable eLearning systems. These requirements include collaboration, learner-centred features, leadership development and the reuse of the learning materials. As a result, achieving individual and social requirements for eLearning systems would provide a higher quality of learning and teaching, as well as better opportunities for learning and increasing the human and social sustainability.

Keywords: eLearning Systems; Sustainability; Learning; Teaching; Requirements Engineering.

1. Introduction

Rapid changes in society and technology demand that everyone could gain and update their knowledge and skills in distance education. Formal classes have been partially replaced or augmented by self-directed learning and flipped classrooms. According to Rahanu et al. (2015), over the last 30 years, a teacher-centred approach has been shifted to a learner-centred approach because of the development of information and communication technologies and the social media revolution.

An eLearning system can be defined as an educational solution to deliver knowledge, facilitate learning and improve performance by creating, using and managing appropriate technological processes and resources, cf. Ghirardini (2011) and Richey (2008). One popular example of the eLearning system is Learning Management System (LMS) that includes virtual classroom, collaboration functions, and instructor-led courses. As per Dagger et al. (2007), an LMS has two types:

- Proprietary LMS, e.g., Blackboard and Desire2Learn, and
- Open-source LMS, e.g., Moodle and Sakai.

Naumann et al. (2011) define sustainable software as "*software, whose direct and indirect negative impacts on economy, society, human beings, and environment that result from development, deployment, and usage of the software are minimal and/or which has a positive effect on sustainable development*". Robertson (2008) defines sustainable e-learning as "*e-learning that has become normative in meeting the needs of the present and future*" and he used active theory in his study to describe when organisational, technological and pedagogic activity systems come into contact to achieve sustainability. In our approach we follow these definitions.

Software sustainability has various dimensions. For example, Goodland (2002) suggested to consider *individual (human), social, economic, and environmental sustainability* dimensions. Penzenstadler and Femmer (2013) as well as Razavian et al. (2014) added to these dimensions a new one: *technical sustainability dimension*. Requirements engineering (RE), i.e., requirements elicitation, evaluation, specification, and design producing the functional and non-functional requirements, is one of the key disciplines in software engineering, as requirements-related errors are often a major cause of the delays in the product delivery and development costs overruns, cf. van Lamsweerde (2008). A number of studies showed that if a software system is developed without taking into account sustainability requirements, this system could have negative impacts on individual, social, technology, economic, and environment sustainability, cf. Berkhout and Hertin (2001), Lago and Jansen (2011), Naumann et al. (2011), Penzenstadler and Femmer (2013), Stepanyan et al. (2013). This is especially important for eLearning systems, as they deal not only with a large amount of teaching data, but also with a large number of users with diverse backgrounds (educational as well as cultural).

In our previous work Alharthi et al. (2015) we introduced a general idea of an RE framework for eLearning systems, with the focus on users' diversity in background, culture, and regulations. The goal of the framework is to contribute to the RE process for development and improvement of eLearning systems, which might improve the overall sustainability of online and on-campus teaching and learning activities.

Contributions: The aim of our current work is to extract, analyse, and combine the results from multiple studies in order to develop an RE framework for sustainable eLearning systems. This paper provides results from multiple studies extracted from Systematic Literature Review (SLR) of sustainable eLearning systems.

Outline: The rest of the paper is organised as follows. Section 2 presents the background for our research as well as related work. Section 3 provides analysis of individual and social sustainability requirements for eLearning systems. Section 4 concludes the paper, discussing the core contribution of the paper and future work.

2. Background and Related Work

There are several studies focusing on the sustainability of eLearning systems. Robertson (2008) proposed in his study a notion of activity theory, and explained when organisational, technological and pedagogic activity systems cooperate to achieve increase sustainability by involving eLearning systems. Stepanyan et al. (2013) reviewed 46 papers limited to publications between 2000 and 2010, and mapped the area of sustainable e-learning three categories having resource management, educational attainment and professional development and innovation. However, their studies covered individual, social and economic dimensions of sustainability, leaving out of scope technical and environmental dimensions.

To enable eLearning to be sustainable, Stewart and Khare (2015) analysed eLearning with respect to ecology, economy, culture, and politics domains and applied the Sustainability Circle Framework that developed by the Global Compact Cities Programme for urban sustainability profile of a particular city or region. This profile has four domains including ecology, economy, culture and politics. There are 7 sub-domains in each main domain in order to assist in assessment through the completion of a survey having 7 questions. The assessment is conducted on a nine-point scale that ranges from 1 being critical to 9 labelled vibrant. This method, which the authors presented, generates a clear graphic representation of the sustainability profile for eLearning systems. However, this framework needs to be reformulated to fit eLearning development. For instance, collaboration, which is part of individual dimension, is not included. Also, sustainability requirements may identify and follow sustainable software engineering in order to cover all the five dimensions and to be standardised with other software domains.

3. Individual and Social Sustainability Requirements for eLearning System

We conducted SLR of sustainability requirements for eLearning systems that determined 15 sustainability requirements from 51 studies limited between 2005 and 2015 and then we classified them to five dimensions of sustainability requirements including individual, social, technical, environmental and economic dimensions. As a result of the SLR, 66% aspects are related to human dimension (individual and social) that we will focus on in this paper.

In the SLR, we followed the dimension differentiations defined by Goodland (2002), Penzenstadler (2014), and Razavian et al. (2014):

- **Individual (human) sustainability:** Individual needs should be protected and supported in dignity and in a way that developments should improve the quality of human life and not threaten human beings;
- **Social sustainability:** Relationship of people within society should be equitable, diverse, connected and democratic;
- **Technical sustainability:** Technology has to cope with changes and evolution in a fair manner of respecting natural resources;
- **Environmental sustainability:** Natural resources have to be protected from human needs and wastes; and
- **Economic sustainability:** A positive economic value and capital should be ensured and preserved.

As presented in Table 1, we distinguish between two types of sustainability requirements: *general* (applicable to other domains, e.g., health systems domain) and eLearning system *specific*. In eHealth services, for example, personalisation feature is essential and assist in improving eHealth services Hine et al. (2008). On the other hand, learner-centred features, reuse of the learning materials, learning object repository belong to education domain only, and should be seen as specific requirements (features) of eLearning systems. Our study has shown that technical, environmental and economic are general sustainability requirements, as they could be identified and analysed for any kind of software.

Furthermore, as result of SRL, we found 34 studies (out of 51 studies we analysed) on the individual and social sustainability requirements of eLearning systems. We classified these studies into three types:

- **Empirical studies:** Knowledge is gained by observations or experience methods. As per Perry et al. (2000), an empirical study is a test comparing what we believe to what we observe in order to help us understand how and what things work;
- **Theoretical or conceptual studies:** Methods consisting of concepts with definition of knowledge being considered to describing a phenomenon of interest[1]; and
- **Hybrid studies:** Combinations of empirical and theoretical studies or other studies such as systematic reviews.

Table 1 Kind of Requirements of Sustainability Requirements of eLearning systems

Dimension	Sustainability Requirements	Type of Requirement
Individual and Social	Personalisation	General
	Learner-Centered Features and Lifelong Learning	**Specific**
	Collaboration	General
	Leadership Development	General
	Privacy and Security	General
	Reuse of the Learning Materials	**Specific**
Technical	Learning Object Repository (LOR)	**Specific**
	Support of Shared Services	General
	Software Quality Requirements e.g. flexibility, and integrability.	General
	Portability	General
	Modularity	General
Environmental	Green and sustainable software engineering	General
	Cloud computing	General
Economic	Reducing the Budget	General
	Ensuring the Growth	General

Figure 1 shows the classification result for the 34 studies on the individual and social sustainability requirements of eLearning systems. The 47% of the studies were classified as an empirical study, while 44% of the studies are theoretical, and 9% have hybrid nature.

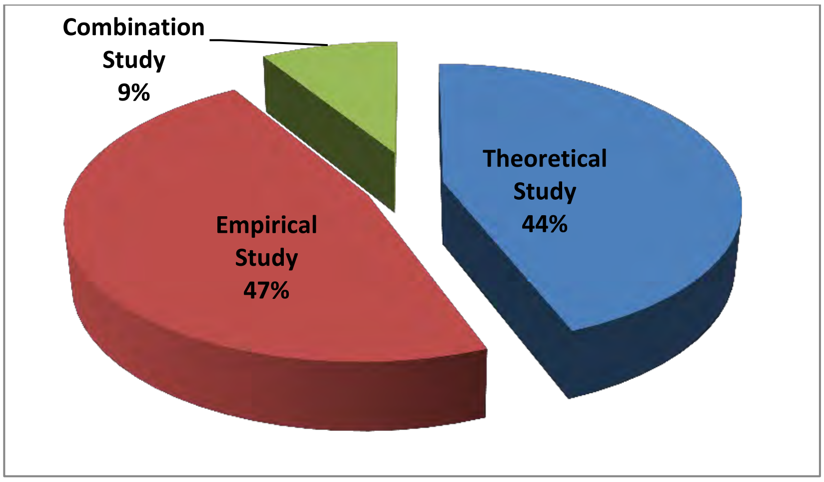

Figure 1 The Classifications of Studies in Percentage

[1] http://libguides.usc.edu/writingguide/theoreticalframework

A few studies from the empirical category, presented are well-structured and well-presented statistical data. For example, Randelin et al. (2013) pointed out the background of participants such as their academic level, gender and age in their study that describing the characteristics of learning programs to promote sustainable well-being at work. On the other hand, some studies did not state the background or academic levels of their participants. For instance, Mridha et al. (2013) claimed that eLearning increases educational equity and English language proficiency has improved but they didn't show how much the increase and the improvement.

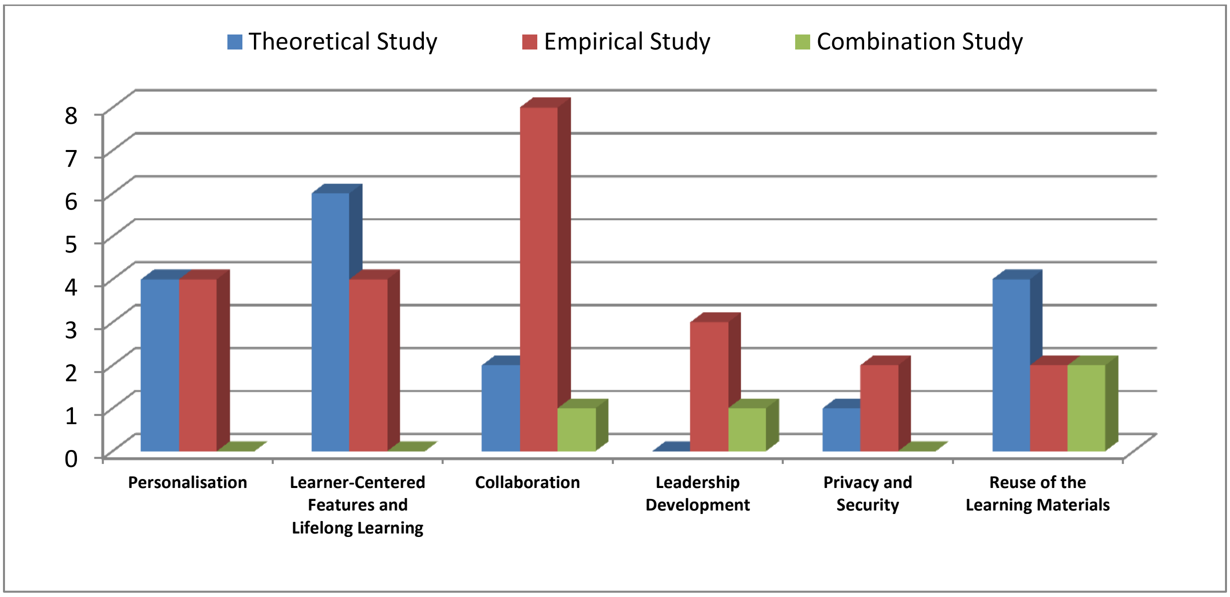

Figure 2 The Classifications of Studies for Each Requirement

Figure 2 illustrates in which study categories the particular individual and social sustainability requirements (listed in Table 1) were identified in the 34 studies. The *Personalisation* requirement was investigated almost both by theoretical and empirical studies in equal proportions, where the *Collaboration* and *Leadership development* requirements were dominantly investigated by using empirical methods, and the *Learner-centred features and life-long learning* and *Reuse of the learning materials* requirements were studied dominantly through theoretical methods. In what follows, we review the studies consistent on the individual and social sustainability requirements for eLearning systems in more details.

3.1 Personalisation

Ros et al. (2013) built a personal learning environment within iGoogle and conducted a survey based on a 5-point scale for 11 questions that have been responded by 150 students from post-graduate and graduate programs in the Faculty of Computer Science, Psychology, and Law. The authors concluded that there is need of the reference models which will let users discover services. Also, a virtual laboratory was implemented with Moodle eLearning system to support free-open resources and personalisation Meneses (2011). Both studies highlighted the demand of personalisation requirements.

3.2 Learner-Centered Features and Lifelong Learning

A virtual world (OpenSim, an open simulator) was integrated with SLOODLE and Moodle environments by Pellas (2014). 94 students used the system and answered a survey having 38 questions. Pellas (2014) proposed that the use of virtual world could increase user's learning ability. Attwell (2007) and Panetsos et al. (2008) explored the idea of lifelong on personal learning environments and academic library activity. The studies highlighted that eLearning systems require the ability to be integrated with the personal learning environment and support learner-centred and lifelong learning.

3.3 Collaboration

Ossiannilsson and Landgren (2012) used three benchmarking (E-xcellence+, the eLearning Benchmarking Exercise, and the e-learning quality model,) during two years in higher education in order to specify the critical success areas of eLearning. Similarly, Sridharan et al. (2010) evaluated the critical success factors of sustainable eLearning. Thus, collaborative technology is one of critical success factors of sustainable eLearning systems along with clear understanding of the pedagogical theory of collaborative learning.

3.4 Leadership Development

Several studies identified leadership development as a requirement of sustainable eLearning systems. Stepanyan et al. (2013) explored the sustainability of eLearning systems and identified professional development and innovation one of three pillars of sustainable eLearning systems. The authors stated that a commitment of continuous development would benefit the adaptation of changes such as instructors training and educational leadership. Konting (2012) also mentioned that there is a need to improve young academic leaders to sustain eLearning systems.

3.5 Privacy and Security

Roy (2012) as well as Stewart and Khare (2015) highlighted that privacy and security aspects of eLearning systems that require significant research. Pardo et al. (2012) proposed authoring system that supporting collaboration, easy re-purposing, and continuous updates. Thus, sustainable eLearning systems should protect users' information and right, and provide a secure environment.

3.6 Reuse of the Learning Materials

Vovides et al. (2014) described a study where five schools participated in implementing an eLearning system to enhance the quality of the training by accessing and reusing digital resources in the Medical Education. The study of Luyt (2015) has shown that it requires eight to twelve months when instructors design their course with the help of an instructional designer. Therefore, the reuse of learning materials will enable designers to provide courses quickly and easily.

4. Conclusion

This paper presents core results of analysis of sustainability requirements for eLearning systems. The analysis was based on the systematic literature review, which included 51 papers. In our current work, we focused on the individual and social sustainability requirements of eLearning systems, described in 34 studies (out of 51 studies we analysed). We classified these studies into three types: empirical, theoretical and hybrid studies, and analysed by what type of study the particular individual and social sustainability requirements were investigated by the authors.

In our future work we are going to conduct a survey on eLearning systems currently used in Australian and Saudi Arabian universities, to develop a sustainability profile framework for sustainable eLearning systems.

Acknowledgements

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Introducing New Paradigms in Basic Control Education Using the YOULA Parameterisation

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Abstract: Course material of basic control theory has been overviewed and updated recently at the Faculty of Electrical Engineering and Informatics, BUTE. In the theoretical material the concept of the YOULA parameterisation has been introduced which gives a new insight into controller design. New lecture notes were written both for the theoretical material and for the MATLAB laboratory exercises. An example demonstrates the design procedure and the gaining effect of robustness of the filters in case of plant/model mismatch.

Keywords: control education, YOULA parameterisation, YOULA regulator, sensitivity

1. Introduction

At the Faculty of Electrical Engineering and Informatics, Budapest University of Technology and Economics, control theory is taught as a basic discipline for all students specialized in informatics. The subject offers fundamental knowledge in analysis and design of continuous and sampled data control systems. The course material has been overviewed and updated recently. Newer ideas for controller design as YOULA parameterisation has also been introduced which gives a new insight into controller design. It is shown that control algorithms like *PID*, dead-beat and Smith predictor control can be considered as special cases of YOULA parameterisation. New university lecture notes were written providing the theoretical material (Keviczky and Bányász (2015), Keviczky etc. (2006, 2009)) and the related MATLAB exercises.

2. Understanding control concepts, introducing the idea of Youla parameterisation

In the sequel it will be shown how the concept of closed-loop control is introduced and how it is related then to the YOULA parameterisation (Keviczky and Bányász (2015)). Control theory deals with the analysis and design of closed loop control systems. The main control structure is based on negative feedback. The goal in control of physical plants is to track the output signal according to a reference signal and to reject the effect of the disturbances. There are requirements set to the performance of the control system. First it has to be stable, then, it has to meet the quality specifications set for steady-state accuracy, dynamic properties such as overshoot, settling time, etc. The control signal has to be inside its technical limits. The control system has to be not very sensitive to measurement noises and to plant/model mismatch. It has to be also technically realizable and eligible to economical and other (e.g. environmental protection) viewpoints.

The control is realized through negative feedback if the input signal (the manipulated variable) of the process is affected by the difference of the measured output signal and its desired prescribed value. The measured output value is generally noisy because of the noise acting on the measurement equipment. Based on the error signal e the controller C generates the manipulated variable u, which modifies the output signal of the process P. The process itself is supposed to be stable. The output signal of the process is changing according to the dynamics of the control circuit until it reaches its desired value. The block-diagram of the closed-loop control system is given in Fig. 1. Often the reference signal is filtered by a pre-compensator element of transfer function (denoted by dotted line in the figure).

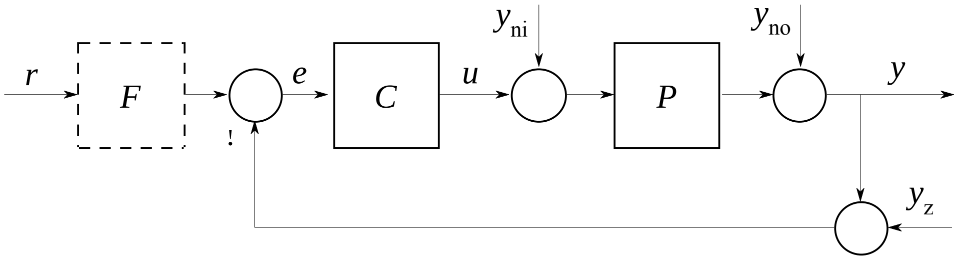

Fig.1. Closed-loop control circuit

If the disturbances and the measurement noise are not considered and the filter is supposed to be unity ($F = 1$), then the open loop circuit shown in Fig. 2. is equivalent to Fig. 1., regarding reference signal tracking.

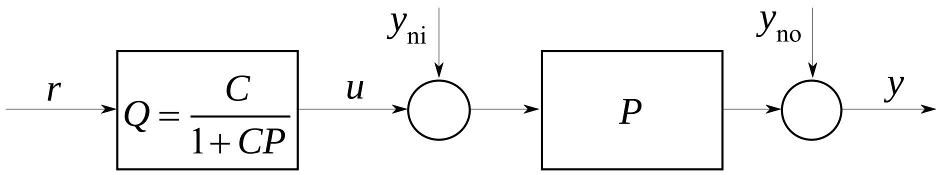

Fig.2. Equivalent open-loop structure

Here Q is the YOULA parameter. The classical YOULA parameterisation gives a very simple way for open-loop stable processes when the regulator can be analytically designed by explicit formulas. The YOULA parameter is, as a matter of fact, a stable regular transfer function. By definition

$$Q(s) = \frac{U(s)}{R(s)} = \frac{C(s)}{1 + C(s)P(s)} \qquad \text{or shortly} \qquad Q = \frac{C}{1+CP} \tag{1}$$

where $C(s)$ is a stabilizing regulator, and $P(s)$ is the transfer function of the stable process.

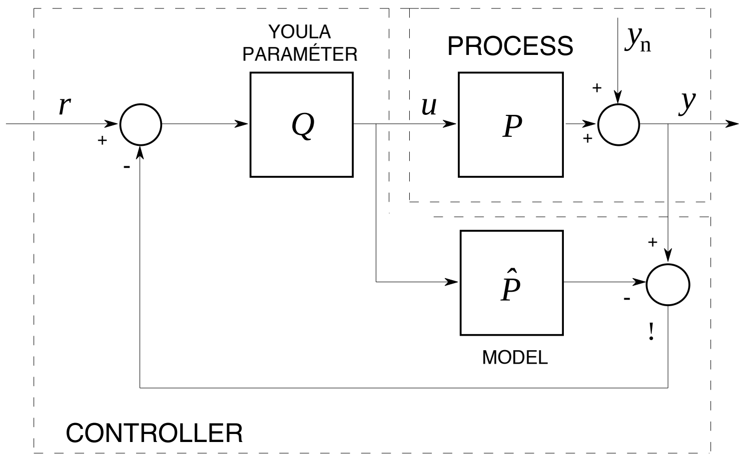

Fig. 3. YOULA parameterised control system with *IMC*

If the process P is stable, then all stable Q controllers ensure stable control system. Similar relationships are obtained for discrete systems as well where instead of the transfer functions the pulse transfer functions are considered.

The open loop structure shown in Fig. 2 ensures reference signal tracking but does not reject the effect of disturbances.

To ensure disturbance rejection as well the open-loop control structure is extended by *IMC* according to Fig.3.

Fig. 4 shows an equivalent block diagram supposing that the model is equal to the system, $\hat{P} = P$. In this usual feedback structure the controller C is expressed by the Q YOULA parameter

$$C(s) = \frac{Q(s)}{1 - Q(s)P(s)}$$

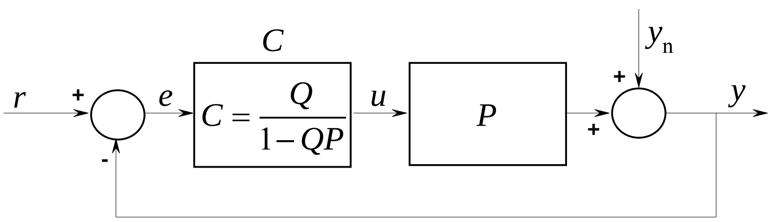

Fig. 4. The usual feedback system with the YOULA parameter in the controller

The best reference signal tracking, when the output signal is exactly equal to the reference signal could be reached if the YOULA parameter is the inverse of the transfer function of the process: $Q = P^{-1}$.

But generally this condition cannot be fulfilled. The dead time of the process cannot be inverted as its inverse is not realizable. It is also not realizable if the numerator of the inverse is of higher degree than that of its denominator. Right side zeros of the transfer function cannot be inverted either, as they will produce unstable poles in the controller. For discrete systems zeros outside of the unit circle cannot be inverted, and cancellation of zeros which lie on the left side of the unit circle (or in the undesired part of the unit circle) is to be avoided as their inversion would cause inter-sampling oscillation.

Therefore Q can be only the inverse of the invertible part of the transfer function of the plant. Let us separate the plant transfer function to the invertible $P_+(s)$ and the noninvertible $\overline{P}_-(s)$ factors, where the latter contains also the dead time.

$$P(s) = P_+(s)\overline{P}_-(s)$$

Then $Q = P_+^{-1}$. The gain of $\overline{P}_-(s)$ has to be 1 as this determines the static gain in the forward path. Figure 5 shows now the *IMC* control structure.

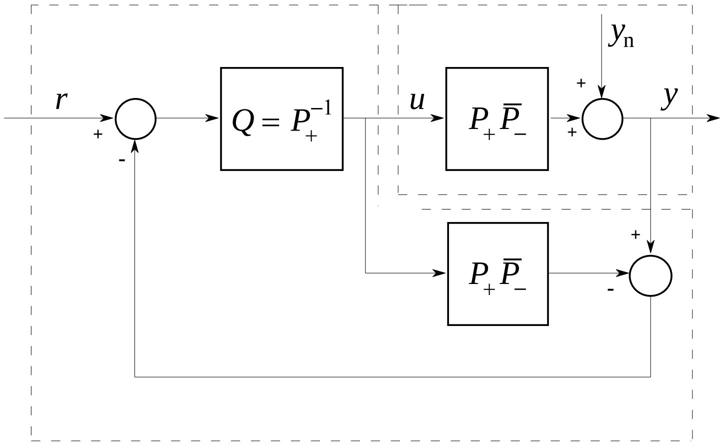

Fig. 5. Realizable YOULA parameterised *IMC* control structure

In this configuration the dynamics of reference signal tracking and disturbance rejection is the same.

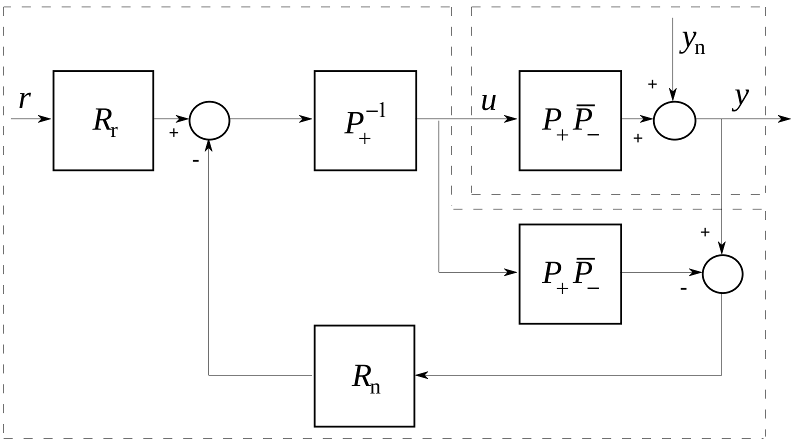

Fig. 6. YOULA parameterised control with filters

If different dynamics are required (e.g., disturbance rejection has to be faster than reference signal tracking), then reference and disturbance filters can be used with unity gain as shown in Fig. 6. This structure is called *2DOF* (two-degree-of-freedom) structure.

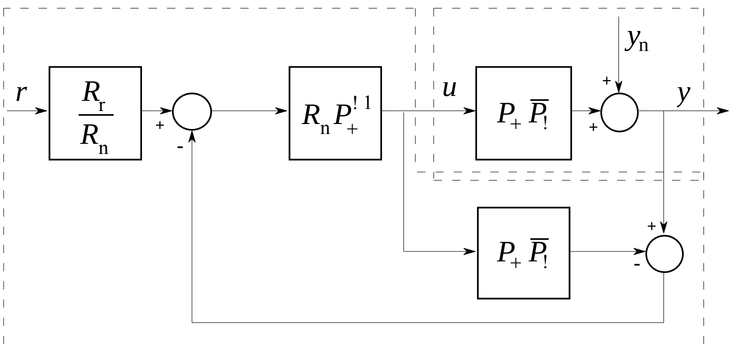

Fig. 7. Equivalent YOULA parameterised *IMC* control system

Equivalent structures are shown in Figs. 7 and 8. Now the YOULA parameter is $Q = R_n P_+^{-1}$.

The series controller is $C = \frac{R_n P_+^{=1}}{1 = R_n \bar{P}_=}$. For discrete systems the relationships are similar with the z-transforms.

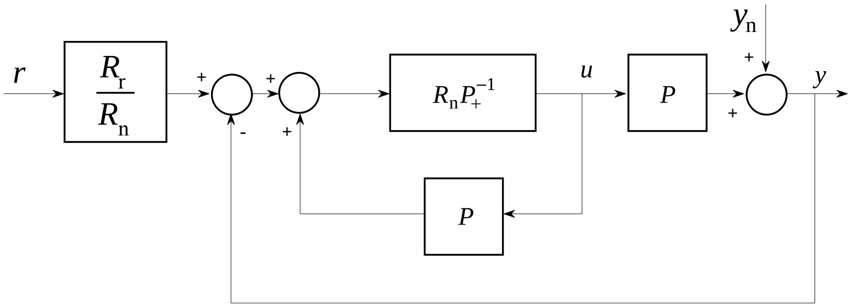

Fig. 8. Equivalent YOULA parameterised control system

Besides ensuring different dynamics for reference signal tracking and disturbance rejection another role of the filters is to modify the value of the control signal u keeping it inside the allowed limits. The filters have also a gaining effect of robustness. With their appropriate choice the control system can be done less sensitive to plant/model mismatch.

Summarizing the design procedure: The plant transfer function has to be separated into its invertible and non-invertible parts. The reference and disturbance filters have to be given as design objectives. The controller can be designed in open-loop, ensuring the best realizable reference signal tracking. Disturbance rejection is provided by enhancing the control with Internal Model Control (*IMC*) structure. The filters have to be chosen considering robustifying criteria.

3. Simulation Example

The transfer function of the continuous plant is

$$P(s) = \frac{1}{(1+5s)(1+10s)} e^{-30s}$$

It is sampled, and zero order hold is applied at the input. The sampling time is $T_s = 5$ sec. The corresponding pulse transfer function is

$$P(z) = \frac{0.1548(z+0.6065)}{(z-0.3679)(z-0.6065)} z^{-6}$$

First a *PID* controller is designed for pole cancellation (cancelling the biggest pole of the system and introducing an integrating effect instead, and cancelling also the second pole introducing a differentiation instead) and for phase margin about $\varphi_m \approx 60^\circ$. The pulse transfer function of the controller is

$$C(z) = 0.3074 \frac{z \,!\, 0.6065}{z \,!\, 1} \frac{z \,!\, 0.3679}{z}$$

Let us design a YOULA controller first without filters, $R_r = R_n = 1$.

Let us separate the pulse transfer function of the plant into invertible and non-invertible parts.

$$\bar{P}_{-}\left(z^{-1}\right)=\frac{\left(1+0.6065\ z^{-1}\right)z^{-1}}{1.6065}z^{-6}$$

$$P_{+}\left(z^{11}\right)=\frac{0.1548\ 11.6065}{\left(1\ 1\ 0.3679\,z^{11}\right)\left(1\ 1\ 0.6065\,z^{11}\right)}$$

and the YOULA parameter is

$$Q\left(z^{-1}\right)=\frac{\left(1-0.3679\,z^{-1}\right)\left(1-0.6065\,z^{-1}\right)}{0.1548\cdot 1.6065}$$

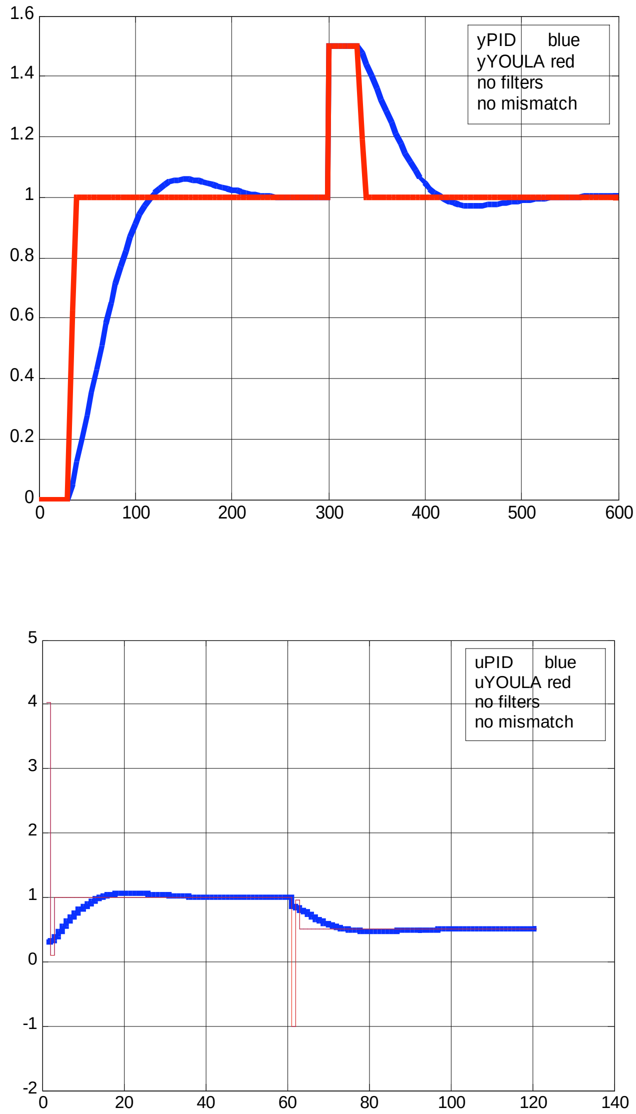

Fig. 9. Output signals (upper figure) and control signals (lower figure) for PID (blue) and Youla (red) control for step input and output disturbance (no filters, no mismatch).

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With first-order lag element filters $R_r(s) = \frac{1}{1+s}$ whose pulse transfer function is $R_r(z^{-1}) = \frac{0.9933z^{-1}}{1-0.006738z^{-1}}$ and $R_n(s) = \frac{1}{1+25s}$ whose pulse transfer function is

$$R_n(z^{-1}) = \frac{0.1813z^{-1}}{1-0.8187z^{-1}}$$

the YOULA parameter is

$$Q = \frac{0.729(1-0.3679z^{-1})(1-0.6065z^{-1})z^{-1}}{1-0.8187z^{-1}}$$

Fig. 9 shows the output and control signal responses or *PID* and YOULA control with no filters and no plant/model mismatch. The step reference signal acts at $t = 0$ sec, and a step disturbance of 0.5 amplitude acts at $t = 300$ sec. It is seen that YOULA control is much faster because of the higher control signal. Fig.10 gives the responses with the filters. It is seen that in the response of the YOULA parameterised controller the dynamics is different for reference signal tracking and for disturbance rejection.

Let us consider the control behaviour in case of plant/model mismatch. The dead time of the system is 40 sec, while in the model 30 sec is considered and the controller has been designed based on this model. The *PID* controller still tolerates this uncertainty, but without the filters the YOULA controller becomes unstable (Fig. 11.). With the given filters its behaviour is acceptable (Fig. 12.).

4. Robustness Considerations for Dead Time Mismatch

Keviczky and Bányász (2012) analysed the relationship of performance and robustness, especially for the case of dead time mismatch (Keviczky etc. (2011). In this case the relative model error is

$$\frac{P-\widehat{P}}{\widehat{P}} = \frac{\Delta}{\widehat{P}} = \frac{P_+e^{-sT_d} - P_+e^{-s\widehat{T}_d}}{P_+e^{-s\widehat{T}_d}} = e^{-\Delta T_d s} - 1$$

and P is the real process and $\widehat{P}$ is its model. It is supposed that the transfer function of the process without the dead time is accurately known, $\widehat{P}_+ = P_+$ and $\Delta T_d = T_d - \widehat{T}_d$

For robust stability

$$\sup_{\omega} \left| e^{-j\Delta T_d \omega} - 1 \right| \le \frac{1}{|R_n(\omega)|}$$

With first-order lag disturbance filter with time constant T_n this condition is expressed as

$$\left| 1 ! \frac{\widehat{T}_d}{T_d} \right| < \frac{\pi}{\sqrt{3}} \frac{T_n}{T_d}$$

With Taylor expansion of the exponential term a simpler robustness condition is obtained as

$$\left|1-\frac{\widehat{T}_{\mathrm{d}}}{T_{\mathrm{d}}}\right|<\frac{T_{\mathrm{n}}}{T_{\mathrm{d}}}$$

In our example the above condition $|1-30/40|<25/40$ is fulfilled.

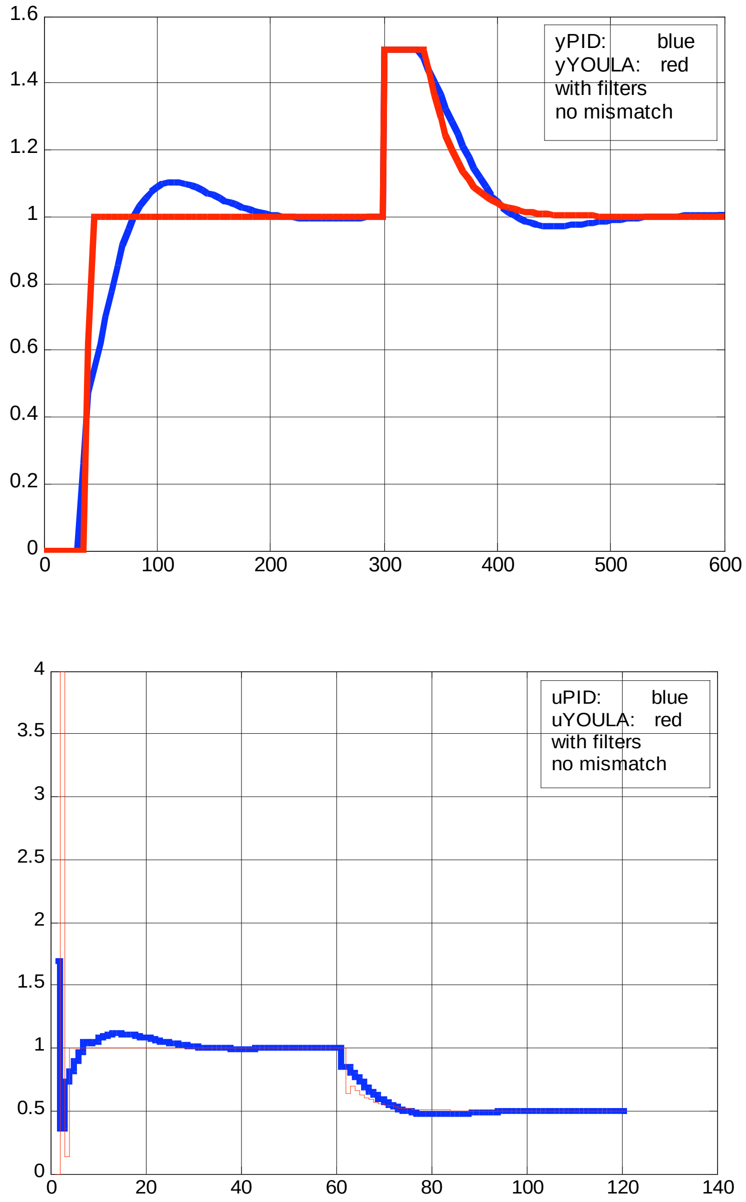
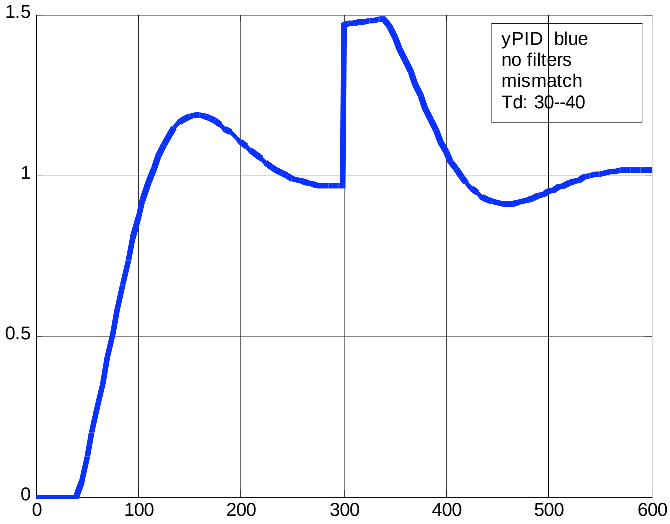


Fig. 10. Output signals (upper figure) and control signals (lower figure) for *PID* (blue) and YOULA (red) control for step input and output disturbance (with filters, no mismatch)

Fig. 13 shows the output signal for $T_{\mathrm{n}}=8$ sec, when the required condition is not fulfilled. In this case the output signal is oscillatory, the control system does not tolerate the mismatch in the dead time. Fig. 14 gives the output signal with $T_{\mathrm{n}}=15$ and 40 sec time constants of the disturbance filter. In these cases the control performance is improved significantly.



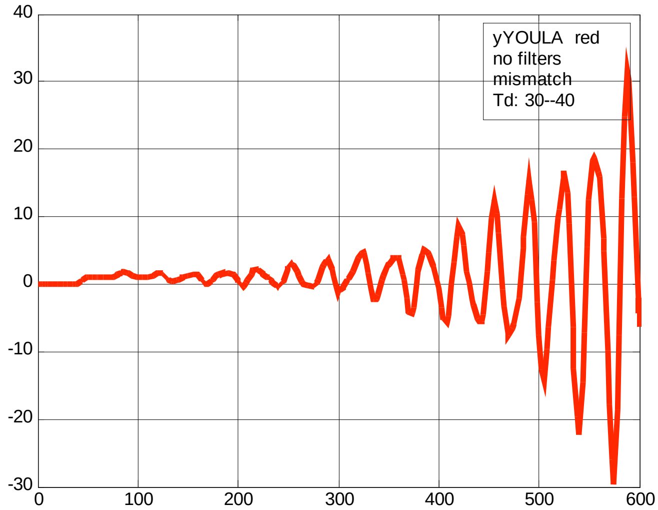


Fig. 11. With mismatch without filters *PID* control is stable, but the YOULA controller becomes unstable

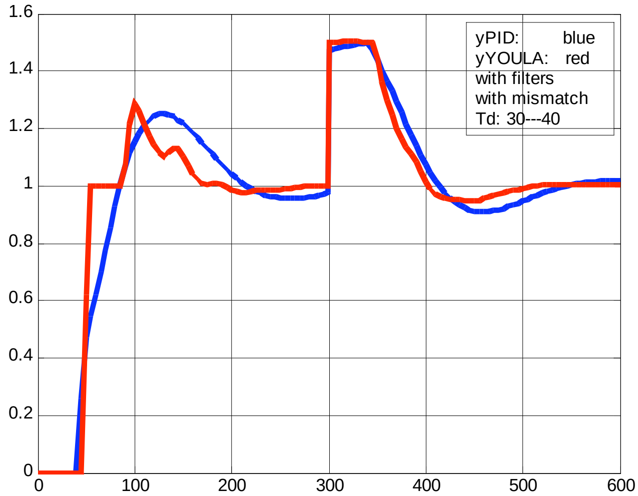
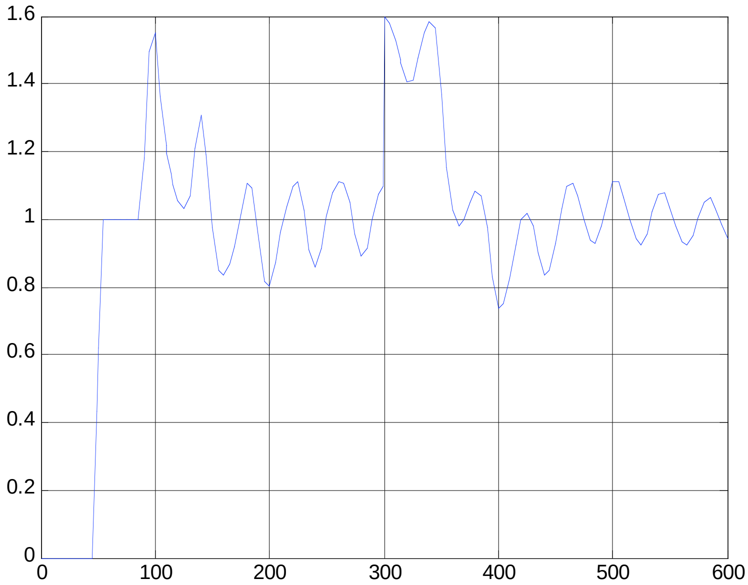


Fig. 12. With mismatch and with filters both *PID* control and the YOULA controller are stable



Fig, 13 With $T_n = 8$ oscillations appear in the output signal

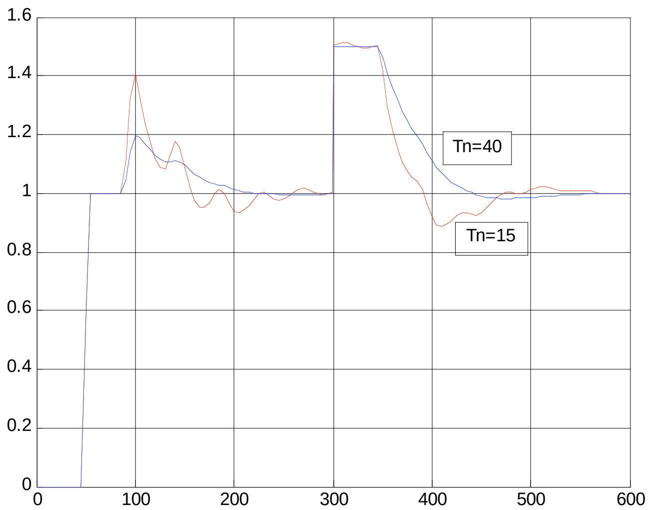


Fig.14. With appropriately chosen disturbance filter the control behaviour can be accepted

5. Conclusion

Youla parameterisation is a very effective control algorithm for control of stable processes. Keviczky and Bányász have researched the structure and several properties of this control paradigm. The controller can be designed in open loop providing the best realizable reference signal tracking, and extending the control system with feedback from the internal model (*IMC*) ensures disturbance rejection. Reference and disturbance filters modify the dynamic behaviour, thus the transients for reference signal tracking and disturbance rejection can be different. Appropriately chosen filters make robust the control behaviour in case of plant/model mismatch and also affect the maximum value of the control signal. It can be shown, that well known controllers like *PID*, dead beat, Smith predictor are special cases of YOULA parameterisation.

This newer approach has been introduced in control education at the Faculty of Electrical Engineering and Informatics, BUTE. The theory is demonstrated through examples in the computer labs using software MATLAB/SIMULINK..

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Studying Elements of Self-Paced Learning and Flipped Classroom to Enhance Course Design

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Abstract: The author writes on differing experiences, forty years apart, with two prominent educational efforts. The first of these is the Personalized System of Instruction (PSI), or self-paced learning (based on work by Keller), introduced in the late 1960's and the early 1970's. The second is the flipped classroom technique. Several features of each method suggest that there may be ways to learn from each. These techniques are contrasted as to objectives, procedures, use of technology, and ways in which they might inform each other, as well as the author's experiences with each. There are differences today, including the ubiquitous availability of electronic resources. In the early 1970's, there were not tools available to faculty, and the procedure was extremely time intensive. We further know much more about just-in-time learning, team-based learning, and project-based learning, among others. It is the author's belief that elements of the two can be combined so as to create an effective hybrid with sufficient variety of approaches to enable individual faculty members to operate within their comfort zones. The key differences revolve around the timeframe for learning and the use of the lecture. PSI also emphasizes instantaneous feedback, as well as increasing difficulty to enable growth in student confidence. Any of the techniques benefit from providing materials available as needed to enable student learning. The paper attempts to integrate known elements to provide a mechanism enabling faculty members to produce their own courses, including knowledge developed earlier where today's tools may enhance its success. Limitations will be reviewed as well.

Keywords: Engineering education, self-paced learning, flipped classroom

1. Introduction

At times, techniques for anything may enjoy popularity and then be replaced by newer techniques that offer promise or may build upon their predecessors using new technology or other new approaches. This has certainly been true in engineering education as well. Sometimes in these transitions, elements that may have value are put aside, and, over time, may be forgotten. This paper is intended to review some techniques brought forth over forty years ago. These will be contrasted with a current approach that has received much attention. Further, findings in the intervening forty years will be included.

The first of these is the Personalized System of Instruction (PSI), or self-paced learning, introduced in the late 1960's and the early 1970's. This effort was based in part on work by the psychologist Keller (1968), as well as the realization that every student enters a class with different backgrounds, expectations, and motivations.

About the same time, faculty at the University of Illinois developed a tool known as PLATO (Burns and Bozeman, 1981). This tool had stored elements describing how to do various things at points where students might have questions. For example, if the student wanted to know something about creating a finite element grid for the problem at hand. The student could click on a figure and be directed to other resources to help with that particular point, such as development of a finite element grid. This tool was clearly a form of just-in-time learning. However, it was available at the time only on desktop computers in university computing laboratories.

The current flipped classroom approach is based on attempting to have each student prepared for engagement with the material by requiring them to watch a video lecture, do some homework, and possibly take a quiz prior to meeting in class to discuss the materials.

There have been numerous findings within engineering education over those forty years, some specifically developed for engineering, with others adapted from other disciplines. For the purposes of this paper, the following will be considered:

* Team-based, collaborative learning
* Project- based learning
* Just-in-time learning

There are other excellent processes and findings, but these seem best suited for this author's effort.

2. Elements of PSI

PSI was popularized by Dr. Billy Koen (1970) of the University of Texas. He and his colleagues received a large grant from the National Science Foundation to study PSI, implement it within a number of classes, and to disseminate findings. The author was fortunate to be selected as a participant in a workshop on the techniques due to his own applications of PSI. The term, PSI, was often cited as self-paced learning, due to students being allowed to proceed at their own pace. Akera (2014) has provided an excellent retrospective on the PSI method and a number of the pragmatic issues that made it decline in use. He further observes that there are many reasons that can support reinvigoration of the PSI method, with research to better define its efficacy. His work suggests that the topic of this paper is timely.

There are numerous elements of this process. A few key ones will be listed here.

- Students can progress at their own pace
- Students can work with other students, but each student is responsible for each quiz, and grading is individual
- Modules must be completed so as to demonstrate mastery before proceeding to the next module. Mastery is typically defined by receiving a grade exceeding a set percentage on a quiz covering the unit materials.
- Modules should be developed so as to enable students to gain confidence, suggesting that earlier modules are less demanding than later ones.
- Immediate feedback to students is needed.
- Faculty members need to develop sets of objectives and questions to guide students through each module
- Class times are set aside to serve as problem solving times
- Lectures are used only as a "reward", due to class progress, or in the event that the faculty member detects difficulties impacting significant numbers of students
- Neither form of lecture looks like a traditional lectures. For example, the diagnostic "lecture" is often a spur-of-the-moment session illustrating solution of a specific problem. (This can also be employed in the context of a team-based, collaborative learning environment.)

- Final grade determination – The purist view would hold to the belief that a student must complete all work with a grade of A. Others would allow a lower grade based upon a number of factors.

In the original version of PSI, five elements are noted:

- Self-paced (i.e., students can proceed at their own pace)
- Learning objectives detailed
- Written materials
- Mastery
- Proctoring

The emphasis on written materials was actually stating that the lecture should not be used until students had achieved sufficient competence to benefit from a lecture on a higher level topic, almost as a reward, but certainly not for content transmission. In today's language, this would encompass texts and prepared notes in addition to any web-based materials, including text, videos, images, and problem solution examples. These latter, non-text items would be part of what the author is herein calling just-in-time materials.

Proctoring, at least as it was originally conceived, entailed having someone with a student as they were taking a quiz. Upon completion, that person (faculty member, teaching assistant, a student more advanced in the class) was charged with grading the quiz on the spot and providing feedback to the quiz-taker. Of course, this procedure also helped to preclude cheating. In addition, this is a very human-time-intensive process.

Mastery is a term with many interpretations.. The purists would argue that this is equivalent to attaining a grade of 100, i.e., a perfect score, on a quiz. This should certainly be the target, but there may be some pragmatic considerations. For example, can quizzes be developed that are sufficiently well cast as to assure that they are not only clear but also robust indicators of student learning. Some people have therefore used some lesser attainment (say 85 or 90 percent) as an indicator of satisfactory performance, or mastery. This area of discussion may need additional research.

A few factors should be mentioned concerning implementation of PSI during its early adoptions.

- Any video prepared To illustrate a point had to be created and then made available to students for viewing, typically through the library for viewing in the library only.

- Teaching by this means was very time-intensive, especially if the faculty member did not have a TA. Each quiz had to be administered by a faculty member (or TA, if so fortunate as to have one), and the quiz was graded on the spot. (some faculty members used student peers for this proctoring role.)

- Since students were able to proceed at their own pace, the faculty member often was dealing with problems and/or quizzes over many topics at the same time.

- Lack of time and technology made it difficult to provide just-in-time materials, leading to further reliance on faculty time.

- The issue of the final grade for the course was a topic of a lot of discussion. If mastery is extended to the entire course, purists argued that all students should receive an A when all modules are mastered. (Therefore, time to completion varied, not level of achievement.) Some others took the view that they would assign different grades depending on how many modules were mastered.

- The author adopted the purist approach to term grades. This led to running into the university administration. For example, in the first semester using the PSI approach for a fluid mechanics course, sixteen students completed work by the end of the traditional semester and received a grade of A. However, fourteen students received an Incomplete and finished successfully the next semester. This received much scrutiny from the university.

3. Description of Flipped Classroom

The flipped classroom is based on students reading material in the book and viewing video lectures prior to coming to class. The viewing is usually followed by homework and quizzes prior to attending classes. The intent is to create an environment where students are prepared to ask questions and better understand any discussion on applications to problems. Brame (2012) is among many who describe the flipped classroom approach. She notes the philosophy and research results from flipped classroom studies. She further notes the following elements of a flipped classroom course:

1. Provide an opportunity for students to gain first exposure prior to class.
2. Provide an incentive for students to prepare for class.
3. Provide a mechanism to assess student understanding.
4. Provide in-class activities that focus on higher level cognitive activities.

The author was asked to teach a section (52 students) of statics. Another section of statics with over 100 students was taught by a bright young faculty member who was using a flipped classroom approach for about the fifth time, and the author felt it best to use his materials and approach for at least the first time. The author notes the following observations from his flipped classroom experience:

- Lecture problems remain - no examples, unless directly embedded within the video
- Homework problem randomization made it hard for study groups to coordinate in working together on problems, plus it creates a large number of potential problems for in-class questions
- Still lockstep – students are still expected to take exams at the same day and time, not allowing self-pacing
- Students got behind and tried to catch up - this was frustrating and also inconsistent with self-pacing

4. Description of Plato Platform

PLATO (Programmed Logic for Automated Teaching Operations) was the first generalized computer assisted instruction system, and it was begun in 1960 at the University of Illinois. The PLATO platform is similar to many activities found on the web today with embedded links. Its relationship to this paper is its ability to deliver just-in-time learning modules to help students grapple with difficult concepts. This just-in-time delivery should lead to enhanced learning as students strive to solve problems and learn. Dr. Charles Vest, former President of MIT and the National Academy of Engineering states that we cannot predict the future, but we do know some characteristics of students, including "…passion, curiosity, engagement, and dreams (2007)." He further states that "In the long run, making universities and engineering schools exciting, creative, adventurous, rigorous, demanding, and empowering milieus is more important than specifying curricular details (2007)."

5. Constraints

There are numerous constraints that may make selection of one aspect of any of the techniques difficult. These may differ from campus to campus, and there may be varying degrees of difficulty.

- Availability of classrooms suitable for active learning
- Campus culture supportive of issuing incomplete grades for students who do not complete the work within a traditional academic calendar unit (i.e., semester or quarter)
- Availability of student help (e.g., teaching assistant(s)) to meet with students for help, to help in larger classroom active-learning sessions, for helping with record-keeping requirements, and for building and improving the library of just-in-time materials
- Development of methods to really engage students in the subject materials prior to class meetings and to hold them accountable for such
- Familiarity of students to team-based procedures. If students have not been exposed to team-based learning previously, there may be some time required to acclimate them to these methods and to bring about their active and effective participation

6. Personal Preferences

Each faculty member has some valuable experiences and objectives, including those committed to one or more of the techniques described here as preferable to a traditional lecture-only approach. Therefore, it is to be expected that numerous combinations may surface. As these efforts increase, it is anticipated that data will begin to be published and shared so as to define conditions under which some approaches are more or less effective, as well as defining various effective combinations.

7. Trial Efforts

For this summer, the author has chosen to use on a trial basis a combination of those activities.

While video lectures were made available to students, they were to be used as resources by the students when they felt they needed additional understanding. The flipped classroom approach was not really fully utilized in this case then. However, the author continued to emphasize the need for students to engage with the material before coming to class. Since the students in this particular class, which is statics, are generally freshmen or sophomores, there needs to be some mechanisms in place for holding them accountable for that engagement. In the previous offering of the course, the author tried to accomplish this by making the homework due prior to the beginning of class. This has the disadvantage that if a student has seen a flipped classroom lecture and read the book but does not understand the material, it reflects itself in difficulties on the homework. For this reason, the author is committed to trying to find ways for them to engage with the material and to have discussions in class focusing on the difficulties they're having to resolve them.

In the classroom, team-based discussion techniques were used. However, it was apparent the students had not yet been exposed to such techniques and had some resistance the classroom itself was not ideal, and it consists of long rows of table tops. However, this made it relatively easy to use pairs by having students turn toward the next student. Practically, it was not difficult to have students in one row turn around and work with students behind. This required some managing and reinforcement as well as encouraging these techniques. This also needs work in future iterations of the course.

An effort was made to keep intact several elements of the PSI method. Specifically, the author tried to retain the following:

- Allowing students to work at their own pace
- Providing instantaneous feedback to students through electronic means
- Requiring mastery on modules through electronic administration of quizzes
- Instituting a final exam to assure that students could understand how to identify the problem and approaches to be used
- Allowing all students who achieved mastery of all units to earn an A

Several of these elements were achieved through use of the Pearson Mastering Engineering program. This enabled the author to post homework assignments, quizzes, and tests for online completion. (Possible academic misconduct will be monitored.) The quizzes were established to determine mastery on modules of material through the course. Therefore, mechanisms had to be developed to enable students to take the quiz again if they did not achieve mastery. The Pearson process allows selection of the specifics test or quiz questions from a larger pool of these. In addition, the numbers for the problems are randomized. As a result, if a student took a quiz multiple times, they would not see the same questions each time. The same is true for tests or exams. Success in the course, including mastery, therefore required students to complete all the modules (or quizzes) by demonstrating mastery. They were then eligible to take the final exam, again online,. Development of the exam required a bit more effort using Pearson tools to assure full coverage. Because the exam for this class is early in the examination period, the opportunity exists to allow students to take the exam again to achieve mastery.

The summer session has meetings every weekday for a total of 39 classes. This makes it somewhat more difficult to achieve the self-paced portion of this because of the rather compressed schedule compared to a traditional semester. In a traditional semester, there would be two class meetings a week, of an hour and 20 minutes each, for a total of 15 weeks or therefore 30 classes. That is a much more relaxed schedule and allows differentiation in the speed of performance and success of the students. In that setting, it is expected that there will be more students who complete earlier, Of course always be a share of students who will have difficulty with some of the materials or difficulty in juggling the various demands on their time between this class and others. Some of these students may not complete the minimum number of modules required to receive a grade of "Incomplete".

8. Future

Efforts will be made to not only solicit input from students on the various approaches, but also to observe performance and comfort levels with the approaches. Perceived difficulties will be noted, and efforts will be made to correct these in the future. The author hopes to begin to gather data from a variety of sources and attempt to do a meta-analysis that indicates the effectiveness of each of the methodologies and, where possible, combinations of them.

9. Conclusions

This paper represents preliminary thinking by the author in an effort to try to integrate findings from several engineering education approaches. It is a work in progress. It also does not address in this forum a number of other approaches that may also play a role in future iterations, such as peer instruction (Mazur, 2009), the use of problem-based and project-based learning, among others. It also does not discuss the role of the rest of the curriculum in such matters as learning team behavior and helping student receptivity to active learning methods. The author intends to continue this activity by a combination of classroom research and educational research.

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Use of Life Cycle Sustainability Assessment in Engineering Courses

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Abstract: Lifecycle sustainability assessment is a relatively new concept, although it is clearly informed by previous efforts. The issue is to try to understand the evaluation of environmental issues, cost, and social issues over the life of a project, product, or policy. Key elements of each of these will be described. It is particularly useful for an engineering course for several reasons. First, it integrates the three elements of sustainability in such a way as to enable students to explore linkages between them. Next, it rather clearly engages other disciplines, an important consideration for sustainable design. Finally, it enables students to explore ways to communicate with varied audiences, including decision makers, an essential skill. This paper presents the three elements of sustainability, life cycle assessment, and analysis and evaluation of the three elements over a life cycle. Means are presented to enable illustration of findings to both expert and non-expert audiences. Specifically, uses of the life cycle sustainability triangle and the life cycle sustainability dashboard will be presented. An example will be presented for a comparison of solar PV panels. Further examples will be presented to illustrate the types and detail of results that can be obtained and contrasted. Inclusion of this important tool is intended to help students better understand linkages between the three elements of sustainability and ways to evaluate them. Descriptions of use within courses, as well as proposed future efforts, will be presented.

Keywords: Engineering education, sustainability, life cycle assessment

1. Introduction

Engineering students are often not fully exposed to all elements of sustainability. This is despite the fact that over twenty years ago, in the Green Report by The Engineering Deans Council and the Corporate Roundtable of the American Society of Engineering Education (1994), one expectation noted is "...an understanding of the societal, economic and environmental impacts of engineering decisions...". This predated the aggregation of these three elements into the overall topic of sustainability, and they have been part of ABET requirements for a number of years. Despite that coverage is uneven, and especially societal impacts are misunderstood or not considered. Exposure to these concepts should help engineering graduates in a world that finds sustainability increasingly relevant and critical.

Lifecycle sustainability assessment is a relatively new concept, although it is clearly informed by previous efforts. The issue is to try to understand the evaluation of environmental issues, cost, and social issues over the life of a project, product, or policy. It is particularly useful for an engineering course for several reasons. First, it integrates the three elements of sustainability in such a way as to enable students to explore linkages between them. Next, it rather clearly engages other disciplines, an important consideration for sustainable design. Finally, it enables students to explore ways to communicate with varied audiences, including decision makers, an essential skill.

Lifecycle sustainability assessment, as noted by Finkbeiner et al (2010) is a relatively new concept that is being used more frequently in energy analyses. The technique seeks understanding of the range of environmental issues, cost, and social issues over the life of a project, product as shown by UNEP (2009) and UNEP (2012), or policy. These three elements taken together provide the basis for assessing sustainability. Figure 1 shows elements of a typical life cycle assessment (LCA). A typical life cycle consists of raw materials, material processing, manufacturing, assembly, product use and end of life, usually with transportation between steps. There are many potential benefits to application of life cycle sustainability assessment as an integrated approach. A few are cited here:

• Organizes data in structured form
• Clarifies trade-offs
• Enables consideration of full range of impacts
• Stimulates innovation
• Helps decision makers
• Enables comparative analyses

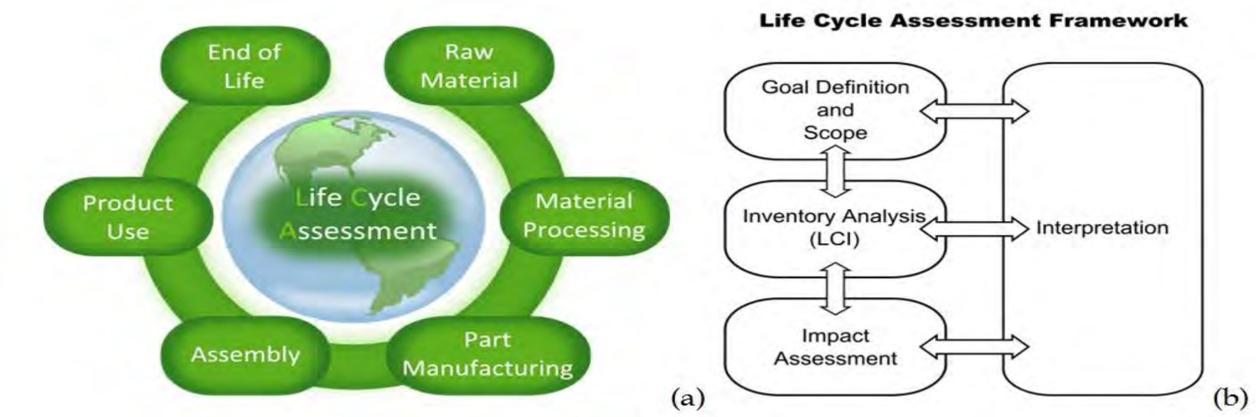

Figure 1 Framework for Life Cycle Assessment

LCA software such as GaBi, Simapro, and OpenLCA have databases and others can be imported. There are free databases, but some require payment of a fee to access them. These are average data from the specific industry and activity and/or product. There are in excess of 70,000 databases. Of course, if local data can be obtained, it is preferable.

Life cycle sustainability assessment has some overlap with the topics of resilience, asset management, and risk assessment. One recent study(Bocchini et al) has shown that sustainability and resilience are becoming more closely aligned in highway infrastructure. The author has been studying these linkages, and it appears that all have a common core of data needs and life cycle concerns. For example, asset management already calls for a life cycle cost analysis.

Coupling life cycle sustainability assessment with scenario planning can enable consideration of uncertainty and assure more robust designs, products, and policies. The major drivers for change include social, technological, environmental, economic, and political. However, one must be wary not to believe that scenario planning has been used just because the word scenario is used, as this may mean a possible course of action (or option) as opposed to a plausible future.

The focus of selected examples is to allow students to study differential impacts. The influence of changing factors can be studied and comparisons made. Students can also see examples where some balancing is required to finalize a design, as some factors perform better on some parameters but not in others. These have been employed primarily in doctoral courses to this time. Students are generally provided the report and supplemental resources. They then work in teams for three to five to identify meaningful findings reported. They are then asked to present brief findings to the rest of the class and to engage in dialogue about their comments.

The dashboard view uses a commonly employed dashboard approach, coupled with color coding to indicate results from very good (typically bright green) to very bad (typically bright red), with shadings between the extremes. This enables a quick view of the overall performance, with alternatives easily compared. Also, results within each of the three elements - environmental life cycle impacts, life cycle costs, and social life cycle assessments - can be seen to help better understand the contributions to overall performance and identify points of redesign and potential investment of resources.

2. Example of PV Module Development

The analysis of PV panels by Traverso et al (2012) is included as a means of illustrating the process and results, as well as an example of a way to visualize the results. It is illustrative of a review of components that might ultimately fit within a larger energy study. The study contrasted production of solar PV modules in two German cases and one in Italy. The functional unit to be the basis of comparison was selected as a square meter. The study used Simapro databases for average values. For example, 21,286 kg of tap water, 4.71 kWh electricity, and 0.11 kg copper, were required for one square meter.

Local data that was collected included data on all raw materials for the German site, as well as aggregated electricity use. For the Italian site, some data was available on raw materials, but most came from existing databases. For the life cycle cost analysis, a questionnaire developed and distributed. Some data was obtained, with other data acquired from databases. One interesting finding showed a significant difference in energy requirements, with the German sites at 0.751 kWh/m2 and the Italian site at 4.711 kWh/m2, both from direct data.

For the Social LCA, several metrics were used. For workers (segmented by age, gender), the study considered these impact categories:

- Discrimination
- Child labor
- Wages
- Working hours
- Social benefits

Health conditions

Results from the study were typically presented in dashboard format. Figure 2 is an example. This figure contrasts the three sites and times for module construction. For each case, environmental LCA (ELCA), life cycle costs (LCC), and social life cycle assessment (SLCA) are included. Those areas in bright green indicate the most favorable performance, with colors approaching red representing the least desirable performance. The color in the central circle suggests the overall performance for that case.

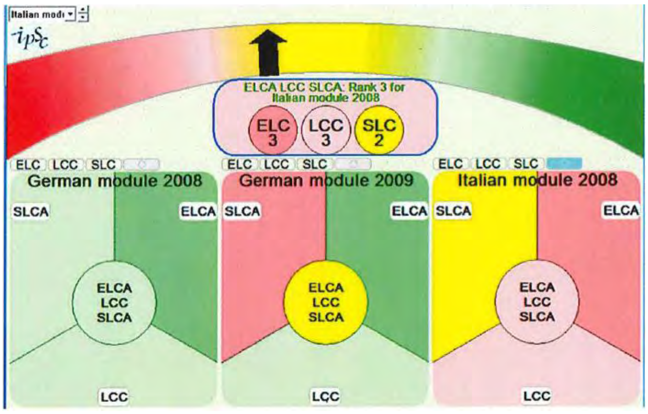

Figure 2 Dashboard Illustration of Three PV Modules by Traverso et al (2012)

3. Example Contrasting Energy Scenarios to 2050 in Mexico

This study by Santoyo-Castelazo et al (2014) uses life cycle sustainability assessment. Eleven scenarios were developed based on different technologies, electricity mixes, and climate change targets. However, each scenario used the same estimated costs for sub-activities, and uncertainties were not studied through scenario planning. Further, the study identified seventeen sustainability metrics. They indicate a number of interesting results. For example, they state "…the business-as-usual scenario, mostly based on fossil fuels, is unsustainable regardless of the preferences for different sustainability criteria. " Santoyo-Castelazo et al (2014). They summarize results as "Overall, the most sustainable scenarios are those with higher penetration of renewables (wind, solar, hydro, geothermal and biomass) and nuclear power. These electricity pathways would enable meeting the national greenhouse gas emission targets by 2050 in a more sustainable way than envisaged by the current policy. However, some trade-offs among the sustainability criteria are needed, particularly with respect to the social impacts. These trade-offs can be explored easily within the decision-support framework to reveal how different stakeholder preferences affect the outcomes of sustainability assessment, thus contributing to more informed decision and policy making." Santoyo-Castelazo et al (2014) The trade-offs mentioned will require engagement of the various stakeholders to develop plans that are balanced and recognize the trade-offs being made, as well as the value of the underlying processes to define impacts.

However, it should be borne in mind that future costs are uncertain and the estimates obtained here are only valid for the assumptions made in the current work. This is a limitation inherent in all studies which consider future costs. Nevertheless, the cost assumptions are consistent across all the scenarios – while the absolute values would change with differing assumptions, the relative difference between the scenarios would still hold. This statement implies that the use of "scenarios" in their work does not imply that they are truly employing scenario planning.

In this study of Mexico, the 'most sustainable' options identified through analyses are the Green, A-3 and C-3 scenarios. If an equal weighting of the sustainability criteria is considered, the Green scenario (with 86% contribution from renewables and 14% from fossil fuels) seems to be the most attractive option; this is also so when assuming that human toxicity is the most important criterion. However, the technical feasibility of this scenario is uncertain owing to a very high penetration of renewables which, in addition to the intermittency issues and small base-load capacity, exceeds the currently estimated potential for some of the renewables. On the other hand, when climate change mitigation, costs and human toxicity are all considered more important than the other criteria, then C-3 (55% renewables, 30% nuclear and 15% fossil) and A-3 (75% renewables, 10% nuclear and 15% fossil) are better options. Therefore, these results suggest which future electricity pathways decision and policy makers should consider for a sustainable development of the energy sector in Mexico.

Major barriers for development of renewable energy in Mexico are related to land and water issues, public awareness and legal and administrative aspects. For example, independent power producers (IPPs) in Mexico have had the experience of purchasing land from 'legal' owners only to find later that people are living illegally on the land but claim it as their own. Relocating these people has been problematic and time-consuming. Another aspect would be local corruption affecting project developers. An example of this was reported when a private company (Fuerza Eolica) contracted a person to act as a community liaison in Baja California to handle the land leasing and community relations, only to find out that he was working for another company and started a land bidding war that raised the price of the land for a wind project development. In general, project developers have found that locals and officials, who study for example the impact of wind turbines on birds and bats, often demand illegal payouts to allow the project to be completed.

Figure 3 shows results for Global Warming Potential for numerous options starting with Business As Usual (BAU). It can be seen that any of the options highly dependent upon coal contribute the most to warming potential.

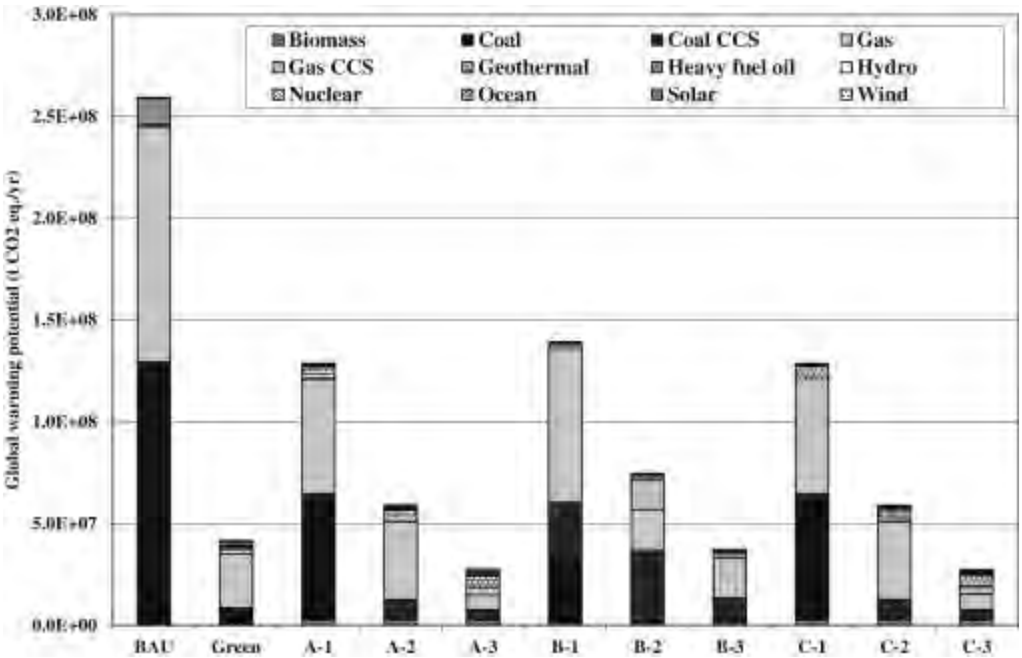

Figure 3 Assessment of Global Warming Potential by Santoyo-Castelazo et al (2014)

4. Example Contrasting Alternative Vehicles

This recent study by Onat et al (2014) compares several types of vehicles across a number of performance measures embedded within the sustainability elements. The vehicles studied include conventional gasoline (ICV), hybrid, plug-in hybrid (PHEV) with four different all-electric ranges, and full battery vehicles (BEV). Two sources of electricity for charging were considered, including use of the ordinary US grid and use of solar charging stations. Nineteen sustainability indicators are included. Results of this analysis revealed that the manufacturing phase is the most influential phase in terms of socio-economic impacts compared to other life cycle phases, whereas operation phase is the most dominant phase in the terms of environmental impacts and some of the socio-economic impacts such as human health and economic cost of emissions. Using solar charging stations reduced the economic costs of emissions and human health impact can be reduced up to forty-five percent and thirty-five percent respectively. "BEV has the lowest greenhouse gas emissions and ecological land footprint per $ of its contribution to the U.S. GDP, and has the lowest ecological footprint per unit of its energy consumption. The only sustainability metrics that does not favor the BEV is the water-energy ratio, where the conventional gasoline vehicle performed best." Onat et al (2014)

The sustainability indicators chosen included global warming potential, water withdrawal, energy consumption, hazardous waste generation, particulate matter formation potential, fisheries, grazing, forestry, cropland, and CO2 uptake (environmental); import, gross operating surplus, gross domestic product, and air emission cost (economics); and employment, government tax, injuries, income, and human health (social). Such studies can decide up front the areas where it is believed that significant impacts will occur. In this study, there were indicators that additional employment might occur as electric vehicles made a more significant penetration into the overall vehicle market.

Figure 4 is one of many presented, specifically for hazardous waste generation in this figure. The hazardous waste generated through the life cycle phases of alternative vehicles are highest for ICVs in Scenario 1, with 71 percent generated in the operation phase of the ICV. Although the BEV generates the least hazardous waste in Scenario 1, it became the worst alternative in Scenario 2 in terms of hazardous waste due to the construction of solar charging stations and the manufacturing of the required materials which respectively account for 62 percent and 34 percent of the total hazardous waste generated to build a solar charging station.

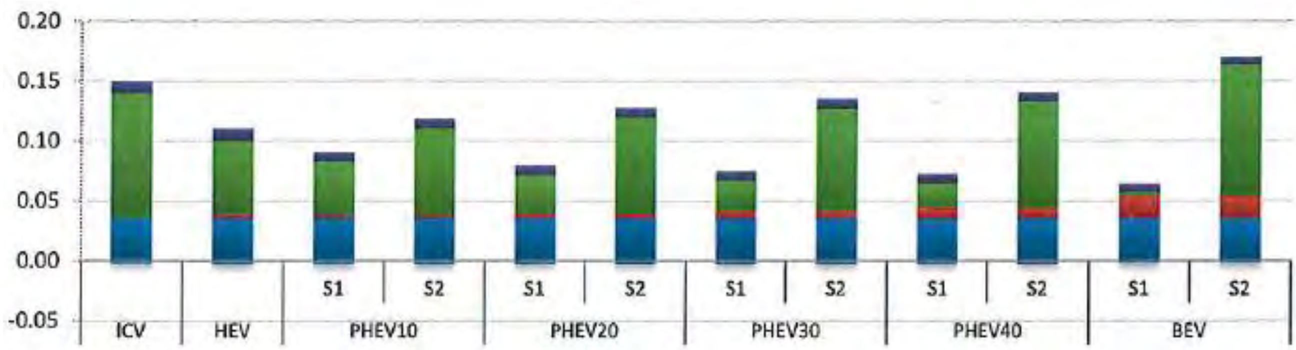

Figure 4 Hazardous Waste Generation Comparisons by Onat et al (2014)

5. Example of UK Electricity Options

This study by Stamford and Azapagic (2014) compares six basic electricity generating processes, with thirty-six indicators of sustainability. The issue under consideration is the ability of the UK to meet mandated greenhouse gas emissions by 2050, as shown in Fig. 3. The six technologies selected were the following: coal (subcritical pulverized) with and without carbon capture and storage (CCS); natural gas (combined cycle gas turbine, CCGT); nuclear (pressurized water reactor, PWR); solar photovoltaics (PV); wind (offshore); and biomass (wood and Miscanthus pellets).

"To meet the GHG emission targets, coal CCS can only play a limited role, contributing 10% to the electricity mix at most; the use of CCS also increases other sustainability impacts compared to today, including worker injuries, large accident fatalities, depletion of fossil fuels and long-term waste storage. This calls into question the case for investing in coal CCS. A very low-carbon mix with nuclear and renewables provides the best overall environmental performance, but some impacts increase, such as terrestrial eco-toxicity." Stamford and Azapagic (2014) Figure 5 shows projections for cases where carbon emissions are expected to be reduced by 65, 80, and 100 percent respectively by 2050. Each of these is, of course, dependent upon a different set of generation mixes and policies.

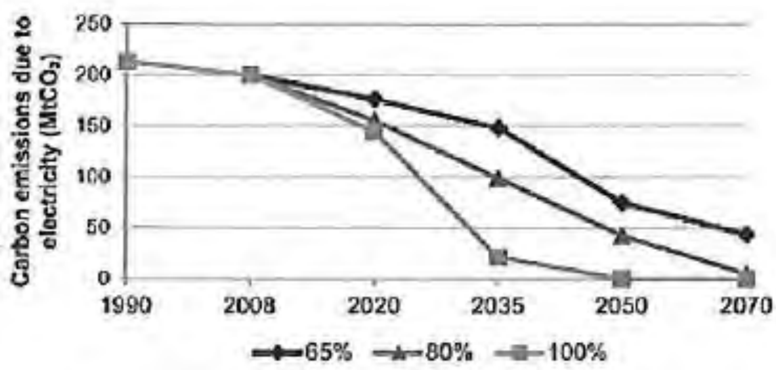

Figure 5 Reductions in Carbon Emissions for Three Options by Stamford and Azapagic (2014)

"With equal weighting assumed for each sustainability impact, the scenario with an equal share of nuclear and renewables is ranked best." Stamford and Azapagic (2014)

The potential use of weighting is a topic worthy of further dialogue as these techniques are advanced. Every project, policy, or product may have different balancing efforts. This reinforces the need to engage stakeholders in the decision process to assure that any weighting used has gained consensus. It further encourages use of parametric studies. By varying the weighting, the effects on the results can be noted. This will enable consideration of those factors with only small influence on the final results, as well as those to which the final outcomes are very sensitive. Further, this will identify those areas which must receive particular attention if scenario planning is coupled with the life cycle sustainability assessment.

6. Future Uses

Given the centrality of sustainability concerns to existing and future energy development, distribution, and use, it seems logical to see increasing use of this tool, and students must be exposed to the techniques. Best results can be achieved by direct and continuous engagement of stakeholders in the data gathering, discussions, decisions, and continuous monitoring for success. Students can be expected to understand the structure and results for such interactions.

If these analyses are done properly, then all costs and impacts will be included, assuring that comparisons are realistic. Several examples have been presented to illustrate applications within several energy areas. Each study chose different indicators for the environmental, economic, and social aspects. There is work to be done to assure most effective utilization. These include, but are not limited to the following:

• Define areas where data and data sources can be used for all or most of the life cycle assessments
• Define the most effective ways to link scenario planning to these assessments
• Determine potential interactions between the various life cycle assessments, where changes in one may impact another.
• Adopt ways to assure that stakeholders are not only included but are essential to the decisions made.
• Perform studies to determine sensitivity of results to data used.
• Study how weighting of indicators may not only change results but also be considered by stakeholders.

In addition to student reviews and reporting as noted based on analysis of the reports, they can be asked to assess the procedures used by report authors. The time required to do some of these studies would be excessive for a single course. In fact, one came from a doctoral dissertation. However, student assessment of the techniques used should help them be prepared to approach their own analyses in the future.

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Development of Summer Outreach STEM Program: Case-Study Smart Lighting

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Abstract: We present high school summer outreach program in science, technology, engineering and mathematics (STEM) areas using Smart Lighting Program as a case study. The continuous improvement or advanced standards of the citizens of any nation depends on continuous research and innovations. The US has enjoys the global leadership role in developing and implementing cutting edge research. However, there are few underrepresented minority groups of researchers and educators in STEM. The contribution of a diverse population of scientists and engineers is necessary to meet the world's needs There is a talented underrepresented group that needs to be tapped and trained for research and improved technology. Under-represented high school students are invited to participate in summer outreach STEM program with the hope that they will pursue college education in STEM areas to improve their employability. We introduce STEM through lectures and hands activities. The program includes daily activities coupled with field trips and presentations. Smart Lighting activities involve application of LEDs and solar power. The participants are introduced to instrumentation and use of mobile studio and Analog discovery. These are portable labs using a PC as the instrumentation.-with dc power supplies and function generators that connect to the hardware (bread board with mounted circuitry). We do assessment for future improvement of future STEM programs..

Keywords: employability, outreach, discovery, assessment.

1. Introduction

Howard University has been one of the Educational Outreach Partners for the Smart Lighting Program which is led by Rensselaer Polytechnic Institute (RPI) and funded by the National Science Foundation (NSF). Howard University's Electrical and Computer Engineering Department has been hosting the smart Lighting Summer program for the past several years. One of the goals of this program is to introduce a wide range of engineering concepts to local High School students and encourage them to later major in Science and Engineering. This is a 4-week program offered in July. Participating students are selected from mostly Washington, DC metro (DC, Virginia, Maryland) area high schools from 10 - 12 graders

During the Summer program, students' learning activities are divided into several modules that are each taught by faculty and mentors. These modules include lectures that provide the theoretical background information about electrical an computer engineering concepts as well as hands on labs that give students practical views and experiences on some engineering systems.
This program is divided into three modules.

Module I, introduction engineering design principles. This guide outlined series of actions and tasks that could lead to a successful analysis, design, and implementation of an engineering project., a list of common engineering terms and their definitions as well as assigned a Solar Powered Aerial cable car project.
Module II: Introduction to engineering concepts, electrical engineering concepts, areas of concentration, and devices such as conductors, semiconductors, insulators, and circuit components such as resistors, capacitors, inductors, diodes and many more. He also gave students hand on projects about AM/FM radios, traffic Light systems , communications (report writing, oral penetrations) and others.

Module III: engineering systems, devices and concepts which included electric circuits, in ways that made them understand easily some of these very complex concepts. valuable feedback to students when they were building their electric circuits, introduction to Python programming presentation about weekly information learned.
A mentor (graduate) student leads the students to conduct several labs activities..
In addition to the three modules, we have invited guest lectures/speakers from industry (such as NASA) to participate in the program.

2. Smart Lighting Institute

The main purpose of the Smart Lighting program is to introduce high school students to pursue engineering education in future that will improve minority skills in their employability as well as make contributions to research. Presently, minority contributions in the STEM areas are rather low. Other similar programs are available on campus. The program introduces the students to general engineering education through lectures and hands on. They learn about electrical terms, quantities and how to use instruments to collecting data. They learn how to use the Analog Discovery whcih is a personal instrumentation that contains function generator with leads that connect to bread boar and then to the computer. It has dc power supplies as well as other signals. The computer is used as scope to measure voltages, currents and waveforms.

3. Lectures

The program consists of 3 main modules plus guest lectures form industry. Each instructor (with mentors) with different backgrounds conduct the assigned module

3.1 Module I:

Introduction to engineering design principles and related assigned projects that. Frequently used vocabulary and key terms in science and engineering are first outlined and defined, as follows
Terms outline:

- Hypothesis- an educated guess or prediction to make
- Independent variable- controlled by the experimenter, maybe a measure of a parameter to determine the outcome
- Dependent variable- variations because of independent variables observed or measured to collect data.
- Constant parameters- remain the same

- Quantitative observations- use of numbers to describe objects such mass, volume
- Qualitative observations- use of words to describe objects appearance, color, texture
- Inferences - an attempt to interpret observations
- Questions- answers to the experiment.

After the above vocabulary and key terms are introduced, the instructor discusses the engineering design project guide that includes a set of steps to be followed in order to successfully complete an engineering analysis and design project. Outlined below

- Getting started, gathering data, generating ideas, implementing solution
- Engineering design process, define the problem, design notebook
- Background research, specifications
- Brainstorm, multiple solutions choose optimal design
- Implementing a solution- development work, prototyping, test and redesign

After discussing the above necessary background for a successful completion of design project, students are assigned to solar-powered aerial cable car project in activities section.

3.2. Module II

Lectures involve circuit theory, introduction to semiconductors with emphasis on LEDs and applications. hands on labs, instrumentation are. Students learn how to use the analog discovery, a persona; instrumentation with built function generator and dc power supplies +/- 5 V. It works for analog and digital labs. concepts of conductors, semiconductors, insulators, AM radios, traffic light system, Figure 2, the functions and characteristics of circuits elements such as resistors (color code), capacitors, inductors, diode, soldering techniques.

AM/FM: Lectures to students in the area of communications. Fundamental concepts of Amplitude Modulation, how a message signal can be modulated by a carrier signal to produce an AM signal on the transmitter side. On the receiver side, demodulate is explained how to recover the AM signal. Students are also shown two videos about how Amplitude Modulation and Demodulation work. After learning about the basic fundamentals of AM/FM systems, students are given an AM/FM radio kit with block diagram shown in Figure 3, an instruction manual containing the parts list needed for construction, and then asked to build the radio by soldering.

3.3 Module III

Provides students a wide range of activities such as Python Programming, circuit constructions, power point presentations, report writing. The lab activities include building circuits with topics about resistors, Ohm's Law and voltage divider, signal generators and waveforms, capacitors and time constant, inductors and resonance and

3D-Printer. The Python programming includes topics about Functions, variables, If Statements and many more.

4. Activities

Each module has lectures are coupled with hands on activities.

4.1 Solar-Powered Cable car

This experiment uses a cable car that utilizes a solar panel to power it. The Aerial Solar Cable Car experiment encourages students to learn about how a solar panel works, the cable car works and what causes it to move based on design principles they pull from user profiles. This activity also encourages students to iterate on their designs and practice using different ideas and data.

This exercise is a great way to push students to build, test and iterate while keeping their designs founded in engineering education. This activity also encourages critical thinking by asking students to synthesize their user's profile to find their needs. Students must also demonstrate strength in the face of challenges or frustrations.

Specifications: Solar panel output 1.1 V, 75 mA, size: 11mm x110mmx180mm, unit wt 2.9 oz

solar cell life 2 years normal use, Motor Dc, power consumption 1.2 Vx10mA, Tools needed: diagonal cutter,, screw driver, scissors.

Materials: Each group (size 4-8, total 40 students) receives transport cable, automatic round trip return stoppers, solar panel and 30 plastic parts to assemble will be provided. Students will receive parts to build the item shown in Figure 1.

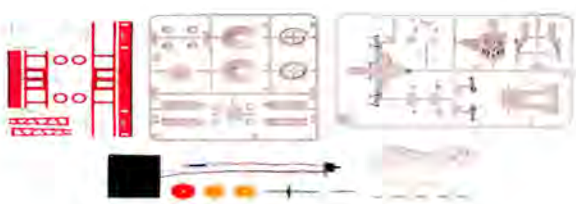

Figure 1. Solar powered aerial cable car parts and view

List of materials per team needed and a detailed step-by-step experimental procedure to complete the project's measurements and data gathering are outlined as follows: Parts-Solar cell, cable car, string, 2 poles, marker, stopwatch, pole/shadow, protractor, chalk

Procedure:

- First, assemble the Aerial Cable Car., Next, arrange two poles on a level grassy area.
- Place the poles at least 54 inches apart from each other, attach the end of a string to each pole. Measure the poles at a 105 degree angle, if possible. Place the cable on the string.
- Place the string under the plastic wheel and up and around the pulley.
- Position the solar panel flat. Time the cable car at least 4 different hours.
- Examples: 12:30, 1:30, 2:30 and 3:30pm on a sunny day, or pick your own.
- The cable car is expected to go back and forth on the string at least six times each trial.
- There will be at least two trials per hour. Record the time for each trial with a stopwatch.
- Record the average time for the two trials per hour. Place a pole in the ground at the same angle to the poles with a string. Measure the angle of the shadow of the pole at each hour with a protractor. Use Chalk to draw a line where the protractor is placed. The angle is then recorded.

Each student writes a final project design report it is completed.

Report writing outline: The project report will just entail pulling together the information you have already collected into one document according to: acknowledgments and bibliography, a detailed description of your procedure, data analysis and discussion, results and conclusions.

A. Report format include these sections:

- Outline—to include the following:
    - Cover sheet nd Title of project
    - Abstract (Project Summary) - this is an abbreviated version of your report.
    - Table of contents
    - List of questions, variables, and hypothesis
    - Background research – What you did before starting the experiment
    - Material list
    - Science Project Logbook (your experiment journal)
    - Experimental Procedure
    - Data analysis and discussion- This section is a summary of what you found out in your experiment, observations, data table, and graph(s).
    - Conclusions and Ideas for future research
    - Acknowledgements – thank anyone who helped you with your science project
    - Bibliography – combine with the above.

Students work on this project in several phases; they first assemble the Solar Powered Arial Cable Car and then got outside several times during the day in order to take some measurements such as the speed of the car, the shadow angle with respect to the sun position on the sky..

4.2 Traffic Light Project

After discussing a traffic light system's elements and functions, the students are provided the traffic light kit below. They are asked to read the instructions and assemble all components on the board by soldering and conduct testing.

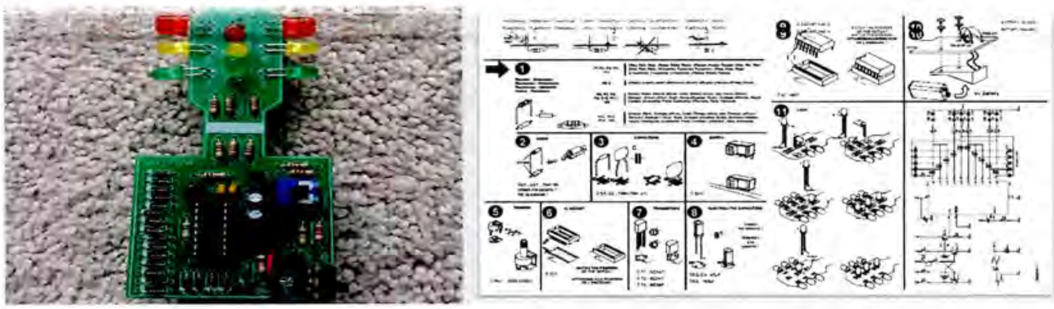

Figure 2 Traffic light kit, parts and instruction manual

In order to construct the traffic light system, students use the information provided in Figure 2. It shows each of the components and a sequence of steps that must be taken for assembly.

4.3 AM/FM Radio Project

After learning about the basic fundamentals of AM/FM communication systems, students are given an AM/FM radio kit with block diagram shown in Figure 3, an instruction manual containing the part list in Figure 2.4, the circuit board and all parts needed for construction, and then asked to build the radio by soldering each component onto the circuit board.

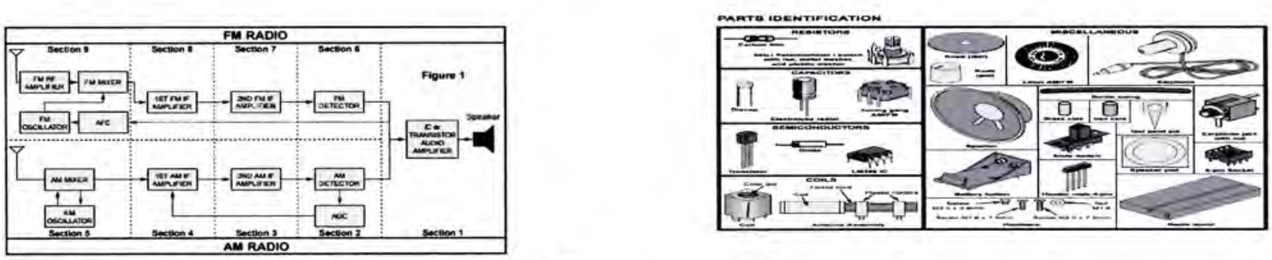

Figure 3: AM/FM radio system, block diagram and parts

4. Lab Hands On Activities

Students are introduced to several lab activities and safety where they learn about electric circuit components, such as resistors, capacitors, inductors, diodes, LEDs. They build and test several circuits using breadboards and the Analog Discovery.

4.1 Sample activities

4.1.1 Activity 1: Resistors

In the first lab activity, students are introduced to the resistor circuit element. They learned about its physical characteristics, how to read a resistor value using its color code, and then measure its value using the Multimeter instrument. Each student is given several resistors and asked to compute the resistor value based on the color code, and then compared it to the value obtained from the Multimeter reading. An example of resistor color code is shown below:

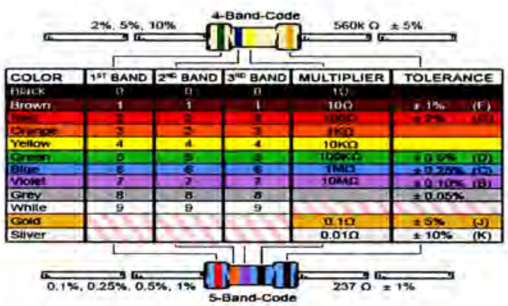

Figure 4: Resistor color code

This Lab is extended to Ohm's Law and voltage divider labs verification

4.1.2 Lab Activity 3: Signal Generators and Waveforms. and Analog discovery

During this lab experiment, students are introduced to the Diligent Analog Discovery instrument. They learn about its internal functions such as Oscilloscope, Arbitrary Waveform Generator, DC voltage generator, Network Analyzer, and others. After learning about the Analog Discovery (AD) instrument, students are asked to use a solder less breadboard and to construct the circuit in Figure 5 using 1 Kilo Ohm resistor and two Light Emitting Diodes (LED). The Analog Discovery is used to generate the sinusoidal input voltage with a frequency that is changed from 1 Hz to 60 Hz with an increment of 5 Hz. Students observe the behavior of each LED (off and on) with different time delay at variable frequencies of the input signal. Also, students used the measurement function built-in the AD to measure input and output voltage characteristics such as amplitudes, frequencies, periods, the input across the voltage source, and LEDs devices.

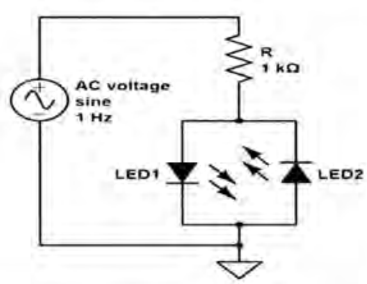

Figure 5 AC Voltage Circuit with flashing LEDs

4.1.3 Lab Activity 4: Capacitors and Time Constant

Students are asked to build on a solderless breadboard the circuit in figure xxx using 1 K-Ohm resistor and a capacitor with value 1 microfarad. The input voltage source is square wave generated from the Analog Discovery with an amplitude of 500 mV and an offset of 500 mV.

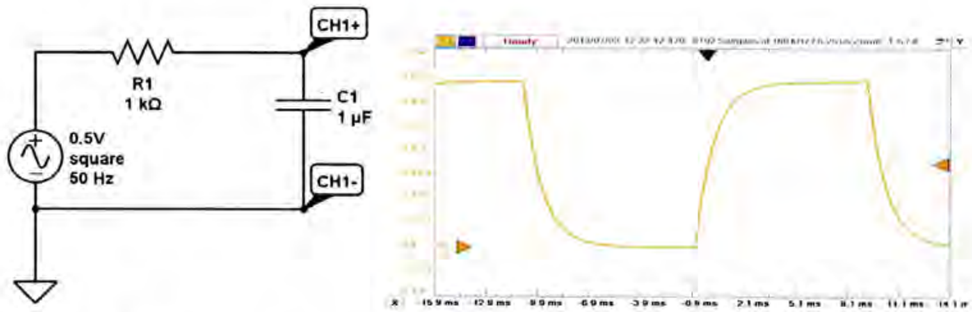

Figure 6 Capacitor Circuit- charge discharge with square wave input

Students are instructed to observe the output waveform across the capacitor using the oscilloscope and to observe that the capacitor is charging and discharge as shown in figure 6. The calculated and measured time constant are also compared.

4.2 3D - Printer Activity

Students are introduced to the 3D-Printer in Figure 7. It can be used to print 3D-objects of difference sizes and forms. The printer comes assembled, the only installation done is about the control software package called Cura.

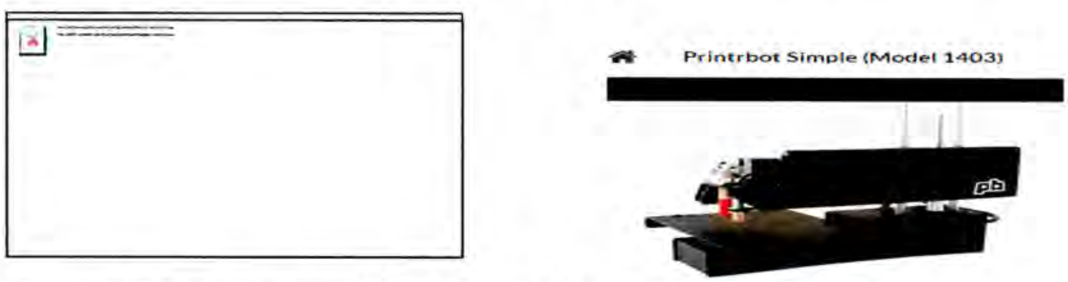

Figure 7 Printer software interface and 3D- Printer

The software is downloaded to the computer connected to the 3d-Printer and several configuration parameters are set. The Interface allows the user to interact with the 3D-Printer in order to load models, set parameters, and print 3D-Objects. Students print 3D-Objects.

4.3 Python Programming

Students learn Python programming and its applications. The activities cover a wide range of Python programming topics: such as: Python If Statements, Variables, Functions, and Loops. A summary follows:

Introduction to Python (Python IDLE)
The Python 2.7 program is designed to be a simple way to begin writing code.

Downloading Python: 1. Follow this link to download: bit.ly/pythonLE27, 2. Run the file and continue until the folder is downloaded, 3. Open the Python 2.7 folder, and open IDLE (Python GUI). 4. Browse through the Python 2.7 or search for IDLE via **Starting to Code.**

Setting Variables: In any programming language, data can be stored in different data types. Variables can be modified and printed. data types **Strings** and **integers**.

Python If Statements: An If Statement is the way programmers ask the computer questions. If Statements are true/false questions that the computer can evaluate. The truth or falsity of a statement determines which steps the computer takes next in a program. If Statements have a particular design. The trigger for an If Statement is the word *if* (no caps).

User Input: Programmers can make the computer ask for user input. **Python Functions:** is a reusable block of code that serves as a template for one or more actions. We have already used the print() function and the input() function. Create your own functions. **Variables: 2** types of variables. **Strings** are groups of characters, and **Integers** are numbers without decimals. Python automatically decides whether something is a String or an Integer. **Input function:** [variable name] = input([Message you want the computer to ask]). Note: You do not type the answer to the question inside the input function! You type the answer after running the program. Example: age = input("Please enter your age: "). **Python Loops:** is a short (one or two line) segment of code that allows the programmer to repeat lines of code until a certain condition is met. Loops encase the code that needs to be repeated. **While Loops:** The While loop looks and works similarly to the If Statement. Loops can easily be integrated into existing programs to make a program that lasts longer and has more utility. **While Loops and Functions:** Lines of code that begin with a hashtag are called **comments** and are not run by the code. Programmers add comments to organize and label different parts of longer programs. numbers and print their sum. **While Loops and Input:** is asking the user whether they would like to run the program again. This combines the input() function and the while loop.

5. Conclusion

Howard University Electrical and Computer Engineering Department hosts the Smart Lighting program each summer where students from local High School are introduced to a wide range of engineering concepts and activities. Learning activities are divided into several modules. In these modules, students are involved in several activities that include lectures and labs using Analog Discovery, a personal instrumentation.. They learn about the engineering design process, AM/ FM radio systems, traffic light systems, Python programming, circuit building and testing, and other engineering concepts and devices. We do pre and post survey assessment of the program. Both results show participants enthusiasm and their desire to pursue STEM areas in their college education. The program is improved on yearly bases based on the students surveys outcomes.

Acknowledgements

Our due thanks to the National Science Foundation (NSF) for supporting the Smart Lighting Summer Institute. Thanks also to participating students, faculty, mentors and invited guest lecturers for making the program a success

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Python Program
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Processing 55 Program

Empowering Teaching and Research to Provide Societal Value

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Abstract: Science Europe is an association with the aim of promoting the collective interests of member states and facilitating collaboration at research policy, funding and performing levels. Much of the work towards achieving the objectives is taken forward by working groups, comprising influential researchers from across Europe. Thanks to three past years membership in the Engineering and Technical sciences committee, main approaches to shaping the future of potentially excellent research are given in this paper, as outputs of team effort. Main feature of the actual strategy to maximize research excellence as well as the overview of actions aiming to face actual challenges are summarized.

Keywords: Research policy, science progress, priority actions, research-based innovation

1. Introduction

Actual research system lacks sufficient capacity to transform knowledge into goods and services, as only 15% of high tech products originate from Europe. There is increasing consensus in scientific community that the core reason rests in the weakness of the research structure and coordination. Generally inventions, as "process of the conversion of cash into ideas" are supposed to arise in the academic world. While innovations, as "the conversion of ideas into cash" is taken care of by the private sector, but the lack of an effective and constructive collaboration between these two sectors blocks the required transfer of knowledge. This difficulty is based mainly on the fact that the objectives and goals of private sector are completely different from those of universities and the communication between the two sectors is often hampered by the increasing interdisciplinary of science, which has become dominant factor in many research areas. This is particularly true for the five key enabling technologies, such as nanotechnologies, biotechnology, advanced materials, advanced manufacturing and processing due their interdisciplinary nature. Especially, these key areas are expected to boost competitiveness, create jobs, and support growth. The adaptation processes, even expensive and always with risk, essentially consisting of nine actions categorized in the contribution, is directly necessary.

2. Main actions for achieving more successful science system

A globally competitive Research Area is a necessity for advancement of science and for knowledge based society. Realising especially the European Research Area (ERA) to its full potential with a strong and effective research system requires actions in a number of key priority areas. The universities and research organisations, the private sector, all have to play their role and take their responsibility to initiate the following nine actions and involving others as appropriate.

Access to quality-assured *research data* is important for the research progress. Sharing knowledge or re-use research results are valuable for support of new research indispensable in verifying research findings as well as accelerating investigation progress. Openness of the data should be the standard, but, it can be sometimes postponed and limited if legitimate reasons apply. There are still a number of others barriers including technical, ethical and socio-cultural ones. The reproduction and easy access implies adequate scientific software, explanatory models, requirements and measures to eliminate scientific misconduct.

Cross-border *collaboration* can evidently enhance the quality of scientific outputs. Research cannot be bound by national borders. International dimension has always been part of scientific landscape, since scientific added value it produces. The objective for the future is to ensure that there are no unnecessary barriers to the support cross-border research. Sufficiently flexible systems and more simple mechanisms should be produced at the conceptual and operational levels. Presently several instruments of this type have been already implemented. MFR (money follows researcher) concept may allow researchers to move to another country taking with the reminder of a grant. MFCL (money follows co-operation line) model allows part of a grant to be used to fund participation of a researcher from another country. Lead Agency Procedure can provide researchers in multilateral co-operation possibility to execute the peer review process and project management only by a single lead agency. In the future, the priority is the identification and dissemination experience, sharing best practices to facilitate cooperation even with countries from outside EU. However, the success of research and innovation should be based on the right balance between co-operation and even competition. Thus diversity and contest between funding programmes at the national and European levels remain indispensable. Effective competition requires consistently high standards, and transnational mechanisms for reviewing and financing cross-border research.

The evaluation, especially ex-post one, and indicator-based assessment of publicly funded research are important tools for international comparison and benchmarking. The *evaluation activities* can facilitate better research and contribute to the effectiveness it generates. Recent studies have demonstrated a diversity of methods and approaches. The development and implementation of standards, appropriate indicators, evaluation processes and methodologies such as impact studies need be promoted. However, excellence needs simplicity that is a set of simple rules in order not to distract researchers from the research itself.

Science progresses if knowledge is shared. Open *access* to scientific *publications* is therefore the next priority. It is defined as unrestricted online access to peer-reviewed, scholarly research papers for reading and productive re-use, not impended by any financial, organisational, legal or technical barriers. Full access to research results strengthens the dissemination, testing and uptake of scientific advances. It enables reuse and exploit of publish material, stimuli innovation and facilitates interdisciplinary research as well as scholarly exchange on a global scale. A common set of principles for the transition to open access to research publications was agreed. However repositories and related facilities are recognised as key strategic research infrastructures. Universities and research organisations are committed to improving their interoperability. The overall objective remains to move from a subscription based “reader pays” system to different business models for research publications.

The topic of research careers includes all factors related to the conditions under which researchers pursue their professional activities. Excellent research is produced when a critical mass of skilled researchers encounter the *optimal conditions* to pursue their ideas, including infrastructures, resources, social and payment conditions. Creating optimal environments for all include equality of opportunity regardless of gender, ethnicity and other factors. Not least mobility plays an important part in career development. Therefore, pension funds and other social security benefits should become truly portable for mobile researchers.

Building, networking or upgrading of major *research infrastructures* are of strategic importance for excellence in research. The majority of funding for the construction and operation of research equipment is granted at the national level. Thus a co-ordination and funding schemes development is presently crucial. Data collection as well as their processing, analysing and archiving are actually important, too. The more mapping of research infrastructures with appropriate minimum quality standards should continue. Rules for external access to research facilities have to be specified for the next networking and forward operational management of research infrastructures.

Research integrity is fundamental to research activity and excellence, scientists´ trust in each other as well as society´s credibility in science. Individual research misconduct can cover a broad spectrum of acts. But fabrication or falsification of data and plagiarism are considered to be the most harmful deviation. The misuse of research data, authorship-related misconduct and inadequate personal or leadership behaviour constitute perhaps even more frequent and questionable research practices. Many institutions, research organisations and universities have put in place structures as well as legislation to promote research integrity and to deal with misconduct. All sanctioning measures must be first preceded by educational and training efforts of researchers aimed at implanting a culture of integrity and at preventing the occurrence of questionable research practice.

Society has changed much under the influence of science and technology. However, some criticism arises from many sides and provokes a decrease of trust in science by the public. *Science in society* refers to activities oriented to strengthen the relationship between science and society, including actions to foster public engagement with science. Scientific organisations should be in the future connected to numerous other actors in society such as industry, policy bodies, civil society and the media and supported by adapted standard towards all sectors of society. The dissemination activities should be an integral part of the research process.

In order to meet the current societal challenges, talented researchers in a globally competitive market independently from their age, religion, ethnic origin and sex must be recruiting. The lack of *diversity dimensions* in the research can negatively impact on the quality of outputs. Equality and diversity issues should be considered to avoid a waste of talents and to ensure excellence as well as innovation.

In addition to the nine outline priority actions, some topics can be essential to maximise actual research impact. Especially countries with less developed research system may face particular challenges, such as loss of human capital. Such disadvantages could be reduced through appropriate measures, primarily through collaboration across regions including *twinning* and *teaming* activities.

Impact of basic and applied research need be demonstrated to advocate for the appropriate funding. The further development of models used to assess research outcomes and impact studies have to be promoted.

Increasingly modern scientific research requires an innovative *interdisciplinary* approach based on integration of knowledge from various areas. A key to future scientific discoveries lies in interdisciplinary research and creating opportunities for both large-scale and small-scale projects that break through disciplinary boundaries. The increased funding for frontier research might help to avoid the danger of neglecting support for basic and fundamental research. The interdisciplinary research will allow the seizing of challenging investigation opportunities, advancing new emerging research topics and attracting the most innovative researchers.

3. Priority initiatives for strengthening innovative research aspects

Research-based innovation capacities are crucial for the use of knowledge to foster positive change in industry, governments and civil society. It is an attempt to change something already established by introducing new services, products or processes to companies, governments or civil society actors, relying on knowledge that was not previously used and that has been acquired through conducting research. At its core, research-based innovation is a team effort, the relationship between individuals and their common work. People with different skills must come together to bring a successful product to the market or implement a novel process in an organisation.

Especially, *researchers* produce new knowledge and have the capacity to comprehend existing knowledge in novel contexts. They also have the capacity to react to new needs exposed by real-world feedback, by refining or extending the knowledge that supports innovation. At that point, *business* persons explore market needs and react by developing a product that answers clients' needs and is financially viable. They seek to balance clients' needs, access to capital, development capacities, and pressure from competitors. Concretely, researchers are often academics, but may also be students or may be employed in private research centres. Business persons may be entrepreneurs, students with an interest in entrepreneurship, established business owners or directors, or product managers in a large company. It is extremely rare that a single person can successfully focus on both of these aspects, especially simultaneously. Some students with an entrepreneurial mind-set may play a business role even though they are trained as researchers, but this inter-sectoral mobility tends to be a one-way path. Successful researchers are driven by curiosity, whereas successful business persons are driven by a desire to manage risk and expectation. The central challenge of research-based innovation is that research and business mindsets are essentially incompatible but must be brought together.

Excellent research produces knowledge that is complex and requires expertise to understand. At best, researchers will produce a prototype. Without active engagement by researchers to help understand the knowledge, business persons will either be unable to fully exploit the knowledge or else its exploitation will be delayed. Traditional linear models fall short in that regard. It is the interaction between researchers and business persons that fosters the dynamics for research-based innovation. To achieve the above, the concept of '*innovation communities'* should be introduced. They are groups of researchers and business persons developing a new product and new knowledge, where the co-ordinated developments of the product and of knowledge are mutually reinforcing.

For a community to exist, its participants must benefit from being part of it, but it must also have a purpose, a structuring force that focuses the community. Successfully engaging in an innovation community with a clear mandate gives researchers reassurance that their knowledge is valuable to the community and can be put forward as a genuine, credible part of the researchers' track record, for the benefit of their career. Business persons aim to ensure that the tangible goals of the innovation community support a viable business plan, so that they minimise the risk of failure in the process and maximise the return on their investment. Tangible goals related to societal value are therefore at the centre of successful innovation communities. They allow researchers and business persons to share a common aim and to build a shared understanding of the purpose of their collaboration.

Research funding and performing organisations should include in their policy-making process the impact of their policies on the ability of researchers to engage in innovation communities. A research system that is based on a narrow definition of the importance of knowledge is not conducive to interdisciplinary research and to research-based innovation. A researcher whose career was in industry may have produced extremely novel and important knowledge, but it will not be evaluated on its merits, because it has not been published in academic journals. A proposal to develop a new service or product should be recognised as a valid or important milestone in a research project proposal. In a context of 'publish or perish' academic careers, this is seen as a major disincentive for engaging in innovation. The *evaluation practices* of research organisations and universities are therefore the foundation for facilitating research-based innovation from the side of researchers. Of course, the evaluation of researchers involved in research-based innovation must also take into account the quality of the innovation community they engage with. Researchers should not be incentivised to engage with innovation communities that are unlikely to lead to successful innovation outcomes, or for which the expected societal goal is of little importance. Defining good evaluation procedures for researchers is one of the greatest challenges of supporting research-based innovation and innovation communities.

Most researchers are not professional innovators, and should not be expected to be. When engaging in an innovation community, researchers should receive *institutional backing*. Working with business persons can be challenging. Thus, policy makers and administrators should encourage the development of personal relationships between researchers and business persons and on creating communities based on trust, fair rewards and common societal goals. The creation of centres or networks should be treated as a tool in support of innovation communities. At the same time, they should promote the understanding that the public research system alone cannot strengthen research-based innovation capacities. To do so require robust commitment from the business community and civil society as well as innovation-friendly public procurement practices.

4. Conclusion

To foster a policy environment that is conducive to research-based innovation, policy makers should include the model of innovation communities in their strategic planning.
Research policy actors should:

- Recognise research-based innovation as an inherent part of excellence-focused research in all disciplines, and notably in engineering, technical and computer sciences.
- Focus their actions related to research-based innovation on the capacity of researchers to engage in innovation communities. The institutional form that supports innovation centres or networks should be treated as a tool, not a goal.
- Communicate regarding the place of research-based innovation in their political mandate, and ensure it is understood by researchers, politicians and other institutional actors.
- Strengthen existing research-based innovation schemes or develop new ones, and evaluate these on the quality of the resulting innovation communities.
- Ensure that researchers engaged in an innovation community are rewarded fairly and that such engagement will not negatively impact on researchers' careers or their future professional evaluation.
- Develop capacities and an organisational culture that allows support for researchers involved in research-based innovation.

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Internal Control In The Financial Sector Via an Information System In Vehicle Tracking Company

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Abstract: This work aims to point out the internal management results for business management in the field of tracking land and sea vehicles, located in an urban area, between the years 2011 to 2013. The methodology took into account the implementation of three internal controls: accounts payable, accounts receivable and billing, in order to provide greater clarity and security to the administrators in their decision-making, ensuring operational excellence. This internal control proved to be able to present through numbers and graphs that you can get an accurate analysis of the performance of the company. The result, in addition to showing a study on accounts payable and accounts receivable also demonstrates the affinity between the financial and logistic sector, to show that financial management is linked to obtaining effective revenue for your organization, avoiding customer dissatisfaction. The research describes an information system which helps the Manager to detect which plans are not being achieved and where there are problems to be corrected. The control system does not indicate directly the cause of the problem, but tells you where the imbalance is evident. This control also helps ensure the adherence of the company to fix the policies, plans, regulations and internal procedures, and reduce the risk of unexpected losses.

Keywords: Information; Vehicle Tracking; Internal Control; Accounts Payable; Accounts Receivable;

1. Introduction

Innovation can happen anytime and anywhere. Innovation is the work of entrepreneurs fighting against the hegemony of the conventional practices. Innovation does not always demand a lot of money or brains gifted. Great ideas born of the imagination of people. From the perspective of enterprises, innovation is to produce billing.

An excellent example of the practice of innovation and their interaction is intrinsically linked with the business environment, leads us to one of the best universities worldwide technology, the Massachusetts Institute of Technology (MIT)-United States, where a study developed by BankBoston, titled "the impact of innovation", it was discovered that over the past 50 years, the students of the institution , famous worldwide for the technological vanguard, founded 4 thousands companies in the 50 American States. Only in 1994, points out the study, employed 1.1 million people and earned 232 billion dollars.

So innovate can be a big difference in the professional development and income generation. But in what areas this reflex can be accentuated? Researchers, engineers and administrators are the most benefited by generating income and employment promoted by innovation. In the most developed countries, the businesses employ 50% to 80% of these professionals. Of the total formal jobs, they take up to 5% to 12% of the vacancies.

Unfortunately, the same is not true in Brazil. According to a study from the National Association for research, development and engineering of innovative companies (Anpei), in the formal market, these professionals (more than 200 thousands) occupy only 1% of jobs. With new guidelines, stimulated by technological innovation law, to allocate more money for research and development, companies should do that number multiply.

Innovations in which are sown strategic models of development in various areas of practice indicate that there are no boundaries to thrive, as well as the revolutionary ideas within companies. Innovation, because it is linked to an entrepreneurial attitude, break concepts must both take place in a small company and in a big.

One of the prophets of innovation was the Austrian economist Joseph Schumpeter, who in the past has proven in several studies that the driving force of economic progress is innovation. Wealth, prosperity, development comes from innovation. For Schumpeter, innovation has a precise meaning: it is replacing old ways for new ways of producing and consuming. New products, new processes, new business models. This substitution is permanent, and he called it "creative destruction"-expression that is used a lot these days. It is this process that causes the capitalist system is the best example in which we can generate wealth and produce economic growth. What Einstein called the "anarchy of the capitalist system" is exactly its strength, according to Schumpeter. Without "creative destruction" there is no wealth.

According to Schumpeter, innovation agents are entrepreneurs. Entrepreneurs are individuals (are people, not institutions, not Governments, not parties) moved "by the dream and the desire of founding a private realm." Because of the "creative destruction", prosperous business men step on land that is permanently "crumbling under his feet". The instability, no balance, inequality and turbulence are inevitable-the price to pay for progress.

These two pillars of Schumpeter's thinking - innovation and entrepreneurship - show that his ideas were revolutionary and drew well parameters present found in all areas of our capitalist system, especially at a time when companies face global competition and without limits.

The graph in Figure 1, define the innovation process from the industrial revolution until the Internet revolution:

Figure 1-the waves of Schumpeter

Source: adapted by the authors of this work

2. Radio Frequency Identification technology (RFID)

The radio frequency identification technology (RFID) has direct impact on day to day logistics processes and people involved throughout the supply chain and sourcing, whether in manufacturing, inventory control, purchase and sale of products. Applying smart tags makes the transmission of information of each product by means of antennas and radio frequency, based on the standards of the electronic product Code. RFID stands for Radio Frequency Identification. Technology, considered the successor to the barcodes, promises to improve storage processes and reading data.

Its mechanism is based on a microchip that stores data and communicates via radio waves with a reading device. It is not just in aggregate more agility to stock control, but also of flexibility: the RFID tag can be edited during the process, by entering new information to ensure the best storage and transportation of the product to its final destination.

There are several areas where this technology is being implemented quickly and effectively, achieving large scale gain in their use, especially in the current focus of most companies seeking to compete in a more incisive in the globalized world in which they are inserted.

The sectors of vehicles and parts, food and electronic equipment are those who demonstrate more RFID acceptance because of the excessive volume of existing items in these sectors and the complexity of managing the supply chain.

The main possible applications, in the view of the professionals involved in its implementation, are related to the Conference process and identification of the receipt and dispatch of goods, followed by the location of products in stock. Another field of application is very promising cargo tracking.

The RFID system is composed of smart antennas, readers, software, electronic tags with smart chip (transponder/Tag/Smart Tag) and a system based on you that makes managing the entire chain of communication via radio frequency.

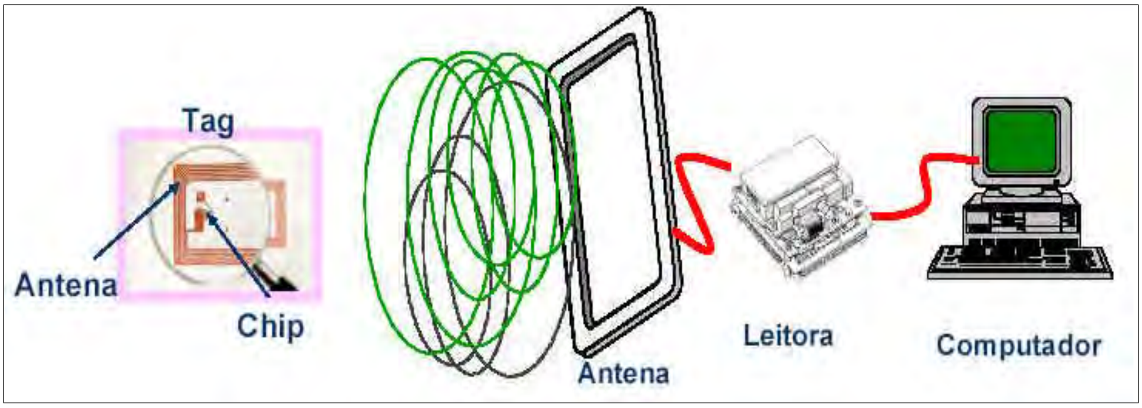


Figure 2 - communication system based on RFID technology

This model can also be increased by a multiplexer equipment to make simultaneous connections to other systems and a scanner/reader, to make collection of the data to be analyzed.

The model in Figure 2 works as follows:

• Reading Tag data

- the Tag enters the RF field
- the RF signal energizes the Tag
- the Tag transmits ID (and other data)
- the Reader captures the data
- the Reader sends data to your computer
- the computer sets the action

• Writing of data to the Tag:

- the computer directs the reader
- the Reader transmits data to the Tag

Below is a detailed description of the components of the RFID communication system for better understanding of how the information is transmitted and encrypted:

a) There is a Transmitter element, called a transponder: that can be a smart tag or "tag", being composed of a coil (antenna), transistor, diode, capacitor and a micro chip. This tag is programmed with unique information to meet the concept of automatic identification, and are fixed on products or objects that need to be identified or tracked, such as: pallets (wooden platform on which stack load), vehicles, and other types of units;
b) Another element makes the function of a receiver, called a transceiver, which can also be described as a reader of information, decoding messages, being composed of an analogue or digital converter and an oscillator. He controls the radio communication and decodes the information transmitted by tags;
c) The third element as shown in Figure 2 is the so-called antenna, which must be attached to the transceiver or reader. Is used to establish communication with the tags or transponder;
d) To do the processing, exist the middleware, which may be a function of the reader interface that compresses the signals of thousands of tags. It forms the interface between the hardware elements and elements of RFID software.
e) Between elements of software, is the transactional system that receives and processes the information decoded by the reader.

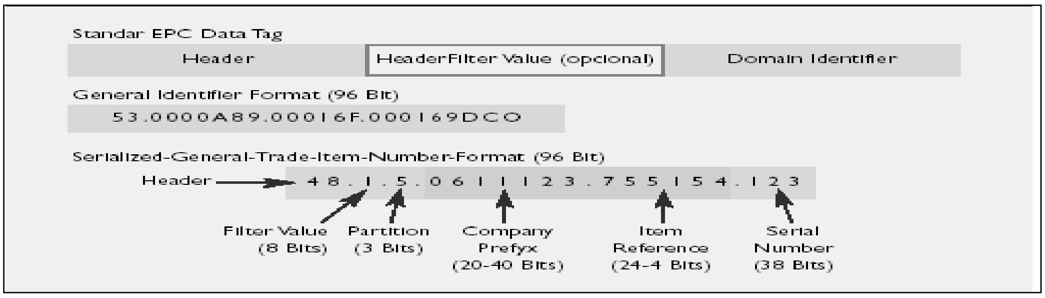
The operation on the data transmission starting from the entry of the object or product containing the smart tag, in the area covered by the tag reader, sending its waves constantly. From the identification of the tag, the reader sends an electromagnetic signal, which is received by the antenna of the tag. In return, the tag transmits a signal modulated to the reader with the information stored.

Communication between the reader and the passive tag, takes place through the identification signal modulation in low frequency ranges (<< 100 MHz) and high frequency (>> 100 MHz) on radio frequencies of the electromagnetic field, which is formed between the antennas.

3. The convergence between the RFID Technology (Radio Frequency Identification) and the logistics chain SCM (Supply Chain Management)

One of the main features, which presents itself as a big competitive advantage compared to other systems, is that every active or passive electronic tag, has a unique serial number, which is known as EPC (Electronic Product Code).

Figure 3 – Format EPC (Electronic Product Code) class 0



Source: A Basic Introduction to RFID technology and Its Use in The Supply Chain

This electronic product code or EPC is defined as standardizing established by MIT (Massachusetts Institute of Technology), in conjunction with the EAN (European Article Number), and the UCC (Uniform Commercial Code), so that it never happen again and that each tag can be identified anywhere in the world.

In addition to this number, the smart tag has a storage capacity through existing, in which memory should store information such as: company product manufacturer, production lot, expiration date, detailed content, among other information, forming in this way a large database about the goods or services for which it is intended, allowing in some cases the change of tag data, by the operator, while she's within your reading field, in mode "Read/Write Tags".

In architecture the mode "Read Tag", your operating system is similar to the well-known barcode, where the preset number on the tag is fixed, and is stored in a central database, and that carrier product reference that particular tag.

Reading labels are cheaper that read/write tags, which makes your system more economical when there are a large number of tags involved. The lowest cost, can also offset the cost of traditional programming and installation of central control systems.

The other way of reading/writing labels, you can continuously update the information contained on the memory label, keeping a record of the process more flexible, without direct involvement of computers, with lower-level management and information exchange of stock.

Information residing in memory of tags are accessed by computer, whenever necessary, to global management functions, while other functions are performed by the RFID controllers. The tag acts as a control mechanism of transport between the "islands of automation" in the distribution center. The label is attached on the product itself or on pallets (wooden platform on which stack load) of the product.

Despite its restricted implementation to business plan of each company, the RFID technology generated a great revolution in logistics chain management, bringing real-time information about the movement and availability of products.

The great advantage that makes the technology very interesting is the possibility of interaction through the ability to access the information, which were inserted on the label at the time of manufacture, and its subsequent update at any time during the movement of the item throughout the logistics chain until its consumption. This becomes the big competitive advantage that will create a paradigm shift in the entire production process.

4. Competitive advantage of RFID technology

In this current commercial management model synthesized by globalization, in which we operate, the technological processes have become determining factors in the Supply Chain Management, even more based with the introduction in the market of smart tags, which through the use of radio frequency, identifying products as speed and greater accuracy in all stages of the production chain in which the system is being implemented.

All studies and investments made by companies in new technologies, captained by its executives focus on increasing efficiency and reducing costs. This constant challenge should always be aligned with the need to deliver products at the right time and at the desired location by its customers.

Today, there are already several technologies developed to meet the demands of Supply Chain, such as the information management systems, Warehouse Management System (WMS), roteirizadores (software that show the best alternative route for deliveries), automation of movement (moving floor, transelevadores), in addition to many softwares to minimize losses and dwindling stocks.

Although considered a technological advancement, increasingly proves that these smart labels tend to be somewhat complementary to the barcode, which is already implemented in all stages of the supply chain and work your way efficiently and with large-scale production.

However, as comparison made in the research, the RFID technology will be critical to supply chain management, bringing real-time information and streamlining objectively, a whole new cycle of production.

Table 1 – Barcode Comparison x smart tag

	Barcode	Smart Tag
Efficiency	Only one tag can be read each time (line of sight)	Able to read multiple tags simultaneously (don't need line of sight)
Reliability	Can be easily damaged	Tags less susceptible to damage
Data	Low storage capacity	High storage capacity
Flexibility	Static information	Dynamic information reusable (ability to read and write)

Source: Prepared by the authors of this work

For a more thorough analysis of the most important factors of the implementation of RFID technology adding value in SCM (Supply Chain Management), we used the Model SWOT (Strenghts, Weakness, Opportunities and Threats) that analyzes the strengths, weaknesses, opportunities and threats in strategic evaluation made for this model making it a great advantage to generate a competitive strategic management.

By this analysis must enumerate the internal environment of the Organization various strengths and weaknesses, as for example:

- The review of all inventory management processes;
- A great cultural barrier formed between sharing information between the industry and the wholesale distributors and retailers;
- Total Mobilization of the Organization on the viability of the project;
- Ensure the reliability of all information systems;
- Investments in hardware and software;
- Integration between the strategic, managerial and operational systems (Executive Management, marketing, operations, logistics, registration, production, inventory, financial, etc.).
- Training and development of staff to operational and technological developments in order to break resistance in the implementation of new processes;
- Strategic changes in design and functionality of the product packaging;
- Redundancy throughout the system, in the event of any faults;
- A coexistence of emerging technologies (smart tag) and effective (Barcode) must create a factor of improvement in application performance.

In relation to the external environment of the Organization, must show that the significant factors are more vital to analyse the opportunities and threats in deploying this new technology:

- Cheapening the cost of chips and readers for their rapid spread;
- Service to the main statutory requirements of the industry;
- Standardization of electronic catalogs to be created;
- Government of the countries concerned establish regulated frequencies;
- Careful Analysis of the sustainability of industrial waste;
- Restricted Selection of partnerships regarding the exchange of sensitive information and cooperation of suppliers and researchers;
- Privacy in relation to the consumer law;
- Absence at the moment of a universal standardization of equipment and frequencies;
- Extension of technology throughout the production chain (SCM).

In the case of technology adoption by businesses, as analyzed by the study, in the wholesaler and retailer if shows important to note as well as competitive advantage generated by the Elimination of costs at the checkout, fast output of products in boxes, accuracy of the information on the survey count of units in stock by reducing many of the problems.

Constant management of information between supermarkets, their distribution centers, its suppliers, an automatic delivery of the products and verification needs demand in retail outlets, ensuring a constant replacement with minimum levels of stock, and use statistical process control software for a follow-up in any part of the world.

The control activities of the productive process, inspection and maintenance operations must be stored in tags and modified by managers and employees allowed in each area of performance. The aftermarket segment also becomes important and strategic, the treatment of the products in case of replacement or need fixing, because the main character transactional data as: day/time of purchase, expiration date, and method of payment, in addition to the customer and product data, need to be properly stored in tags. In this way, you can obtain an immediate identification providing customer loyalty in future purchases, is well attended.

5. Conclusion

This article, looking for size and assess how RFID technology is being inserted in the context of organizations, showing his character and his innovative way in order to make a new concept of business management, with a significant increase in corporate profits and a reduction of operational costs. The great challenge in long-term planning, you will discover the best model to be employed so that the organization can achieve competitive advantage expected and add value to your entire production chain.

The transmission system in the exchange of information with little human interaction effective reduction in transactions raises a great strategic value primarily in the management of SCM supply chains.

The whole success of this technology will depend on the adoption of the corporate strategy and confidence in its performance, to all employees, but especially in industry and consumer acceptance.

Was made a study in 2006, applied to the transport and logistics sector, by consulting firm Eye For Transport, which allows to know the evolution and how companies plan to adopt RFID technology, which indicates that 30% of them are accumulating knowledge with a view to formulating implementation strategy and 35% waiting for the feedback from customers and partners before taking the initiative.

In addition, the study also indicates the phases of development of an RFID Project, where it starts on requirements analysis and technical assistance; mounting a pilot plan and assistance for integration and culminates with the integration of systems and their promotion strategy.

With this implemented, can be seen in a preventive manner, its acceptance and that way you can better visibility and greater prospects of success.

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Development of a Microcontroller Course Using PIC16F1829

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Abstract: This paper presents our experience in developing a microcontroller course using the PICkit 3 starter kit based on the PIC16F1829 microcontroller, taught in six-week duration, at the Western Sydney University. The starter kit was released by Microchip in 2012. The paper elaborates challenges, new course structure, delivery mode, incorporation of active learning and student feedback results. The new contents were taught in 2014-2016. Possible improvement to enhance students experience is also proposed.

Keywords: PIC microcontroller, problem-based-earning, online delivery

1. Introduction

Because of performance –to-cost-ratio and reliability, microcontrollers are widely used in industrial control and instrumentation (medical and defence, and others). Nowadays, microcontrollers are covered in many university programs.

In the Mechatronic Key specialization of the Bachelor of Engineering program, there is a unit called "Microcontrollers & PLCs" [1]. The unit covers two parts: programming of a microcontroller and programming of a PLC, with time equally spent on the two parts. Before 2014, a 8051 microcontroller development board was used for practical experiments in the microcontroller's part.

PIC microcontrollers are manufactured by Microchip, based on RISC instruction sets, targeting at control applications. PIC microcontrollers are easy to program, easy to interface peripherals, and consumes less energy as compared to the 8051 microcontroller, because they can be put to sleep mode. Another benefit is that Microchip provides a lot of support.

There was a demand from students' survey to substitute the 8051 microcontroller with a PIC microcontroller. Hence, it was decided to find a PIC microcontroller-based starter kit.

The search for a suitable PIC microcontroller was started in late 2013. Te main aim is to find a starter kit which is easy for practical task in 2-hour class per student per week for 6 weeks. The total number of starter kits is 25. At that time, starter kits for some 8-bit, 16-bit and 32-bit, PIC microcontrollers, were all considered and compared primarily based on their prices. In the end, the PICkit 3 starter kit [3] was chosen due to cost constraint. 25 sets of the starter kits cost around $2000, intended for use in 4-5 years.

Before the 2014 Spring semester, the microcontroller part of this unit was redeveloped for the PIC16F1829 microcontroller and the teaching plan has been taught in 2014 and 2015.

2. Course Design

A. Programming platform

Programming was implemented on the MPLAB X IDE (integrated development environment). Both assembly and C languages are provided by this IDE. In our development, assembly language is chosen for programming, because we believe, for beginners, assembly language is preferable since it provides more insight into the operation of the microcontroller in its core. On the Microchip website [3], many versions of MPLAB are available for downloading, but only MPLAB version 1.41 or earlier ones work for PIC18F1829. The author spent a lot of time to work on the problem, and eventually, found a solution with the help of a thread in a public forum.

B. Teaching activities

The teaching of the microcontroller programming is conducted in six weeks. There were 2-hour lecture, 1-hour tutorial and 2-hour lab per week per student, for 6 weeks.

Lectures cover the topics of the architecture of PIC16F1829, its instruction set, port programming, analogue to digital conversion, timers and interrupt processing.
In this way, we can still cover topics of computer architecture like IO interfacing, timers, interrupt processing.

Five labs are scheduled in five weeks on the topics: (1) assembly programming and understanding of PIC16F1829 architecture; (2) 16-bit arithmetic operation; (3) parallel port interfacing involving LEDs and switch; (4) A/D conversion; and (5) timers and pulse-width-modulated signal generation. In all labs, students were given programs to run and to make minor changes, to help them understand configuration and practice programming skill. Those programs were selected from [6].

Some authors [4], [5] advocate to use project-based-learning (PBL) tasks for microcontroller labs. PBL tasks demand lots of time on teaching staff and students. Some PBL tasks were set up in this unit. Based on the feedback from students, long programs directly chosen from [6] are hard for students to understand. Thus, first, students were asked to make group oral presentation on the analysis of lab 3 and lab 4, during tutorial sessions. Additionally, students were also asked to complete three small PBL tasks during lab sessions: left –rotation of the 4-bit pattern on LEDs to the left, implementation of counting number of 1s in a file register, and reading a temperature sensor. In the first two tasks, the knowledge of shift operation and bit testing was consolidated, and in the third task, the configuration of ADC module was required.

Tutorials start from the second week after lectures. In tutorials, theoretic topics covered in the previous week's lectures were reviewed along with examples, and assembly programs to be used in labs were explained in details.

In the market, the author was unable to find a suitable textbook for teaching PIC16F1829 in six-week time. Therefore, based on the information in [7], the author wrote a textbook for PIC16F1829 with an emphasis on the PICkit 3 starter kit for this course.

C. Assessment

The unit comprises two assessment components for the microcontroller's part: lab completion (20%) and an open-book individual final exam (30%).

3. Discussion and Conclusion

A. Shortcoming of the PICkit 3 starter kit

Figure 1 shows the programmer for the PIC16F1829 microcontroller and Figure 2 shows the associated demo board. The PIC16F1829 microcontroller is located on the board shown in Figure 2. From figure 2, one can see that only one push button, four LEDs, one potential meter used to simulate analogue device, are included in the demo board.

Figure 1: PICkit 3 Microcontroller Programmer

Figure 2: PICkit 3 Demo Board

B. Conclusion

This paper describes our experience in teaching a 6-week microcontroller unit. It is planned to setup more hands-on tasks such as interfacing distance sensor and temperature display on a LCD screen, to further motivate students' interest in microcontroller programming. We wish our experience is useful to colleagues in the same area.

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Design, Development and Administration: Best Practices for Future Engineering Full Online Courses

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Abstract: This paper presents the experiences in developing a short course for continuing education on Environmental Sustainability. The course was fully delivered online using a Learning Management System (LMS) and the course design was developed using an adaptation of the Brain Targeted Teaching Model. The material and educational strategies were the product of a collaboration between an Electrical Engineering professor, and a Distance Education specialist, with the support of a technical team in multimedia creation and instructional design. The experience was used to identify the 10 best online course design practices, and the 20 best administration practices of an online course teaching. The experience and best practices are presented as a guide to future development of regular courses in Engineering and other disciplines. Dr. Mariale Hardiman developed the Brain Targeted Teaching Model. This model served as a bridge between research and practice by providing a cohesive, proven, and usable practice for effective instruction. Compatible with other professional development programs, this model shows how to apply relevant research from the educational and cognitive neuroscience to the educational settings through a pedagogical framework. The model's six components are: (1) Establish the emotional connection to learning, (2) Develop the physical learning environment (virtual adaptation), (3) Design the learning experience, (4) Teach for the mastery of content, skills, and concepts, (5) Teach for the extension and application of knowledge, and (6) Evaluate learning. The process and results will be presented.

Keywords: Engineering education, online course, best practices, student perceptions

1. Introduction

This model was used to establish the design process and online course administration by the Center for Resources and Distant Education (in Spanish, CREAD) at the University of Puerto Rico, Mayagüez Campus. Adjustments were made to the model, which was originally created for the traditional classroom and this yielded the 10 best practices for online course design and 20 best administration practices of an online course in a LMS. Both the model and best practices have successfully been tested and continue to be tested on online short courses facilitated by the Program of Short Courses and Special Projects at the Division of Continued Education and Professional Studies at our campus. In these courses, we serve participants from all over the island of Puerto Rico as well as from abroad. We understand this is the ideal model and the most current to successfully develop an online continued education and possibly courses at all levels. The online modality allows students to be life-long learners by facilitating time, participation without geographic barriers, and access to information and resources.

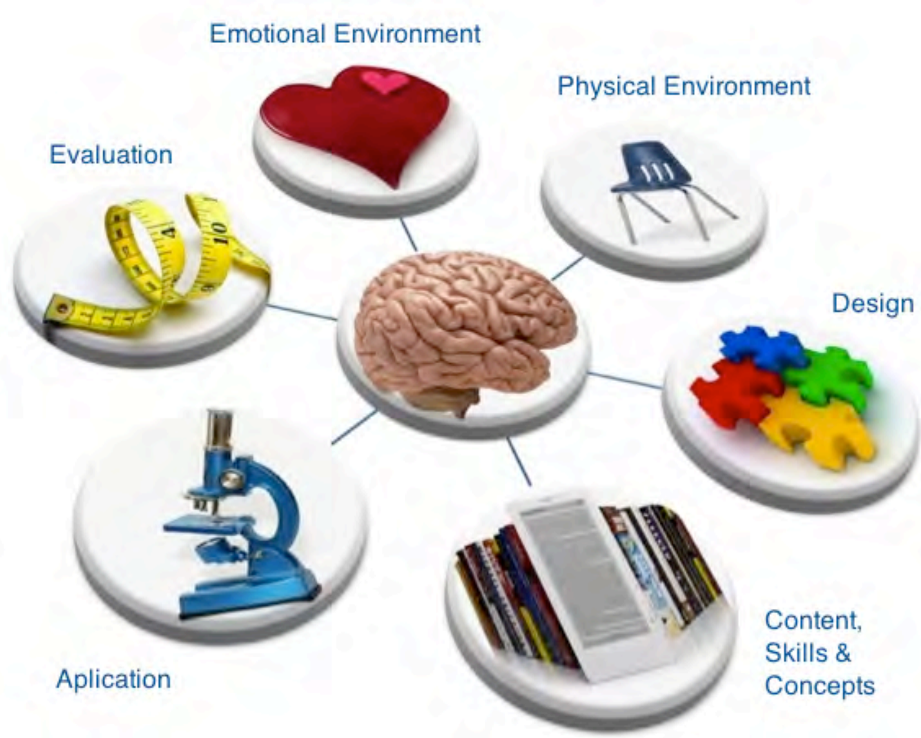

Figure 1 Brain Targeted Teaching Model

1.1 Model adaptation for online education

The six components of the model, summarized in Figure 1, are briefly described below as well as the implications in the design and administration of an online course.

1.1.1 Establish the emotional connection to learning

This part of the model deals with the interconnection of emotions and learning. Planning is based on the understanding of the positive and negative alert states, attention, memory, and higher order thinking. For example, research shows the negative effect stress has at all levels of learning. Research has also shown that using strategies, which make learning pleasant and positive, increase academic progress. These emotional connections must be taken into consideration to relate more closely with students and make their learning significant and relevant.

1.1.2 Develop the virtual learning environment (adaptation - originally: physical)

Just as the emotional connection can shape learning, the elements in the virtual environment may influence students' learning attention and compromise their tasks. In distant education or online courses, the virtual environment, and its design, is an important part of the learning experience. It is imperative that faculty or the institution understands how the design of the platform can help or hinder in creating an adequate and effective virtual environment.

1.1.3 Design the learning experience

According to cognitive science, the learning processes are associated with processing information; this is how meaning is developed and how a relation is perceived through the senses. What is known is used to categorize new stimulus and both knowledge combines to create thinking and learning patterns. Cognitive science indicates that knowledge is organized around a global understanding or big ideas. Therefore, learning experiences should be developed by presenting students with the big ideas of concepts, and connect these to their previous knowledge.

1.1.4 Teach for the mastery of content, skills, and concepts

The goal of education is the integral development of the human being, to make them productive and life-long learners. This requires that students learn the content, skills and concepts by retaining information and using it in significant ways. It is important for educators to know how the connections between learning and memory work. The educator should understand how information and experiences are processed, how they are codified, stored and later retrieved. Investigations in the area of cognitive and psychological sciences offer strategies on how long-term memory is stored.

1.1.5 Teach for the extension and application of knowledge: Creativity and innovation in education

In the 21st century, it is not enough to just master the content, skills and concepts; the use of this knowledge for real-life problem solving, should be promoted. When designing online courses, new findings in neuroscience should be used, alongside instructional strategies.

1.1.6 Evaluate learning

This is a critical component in the teaching learning processes. Continuous evaluations improve learning and memory. It is important to design and use assessment tools that go beyond traditional assessment such as products generated by students, portfolios, and assessment based on execution of tasks.

2. Method

A quantitative methodology with descriptive approach and survey design was used for this study. The descriptive approach is to "investigate the incidence and values that manifest one or more variables (within the quantitative approach) or locate, categorize and provide a vision of a community, an event, a context, a phenomenon, or situation" as described in Hernández, Fernández, & Baptista (2006). Spontaneous qualitative data was collated during the course. The professor was also interviewed after the completion of the course.

2.1 Course Design Process

The professor is asked to develop the name, description of the course and the list of topics to be covered. This provides the instructional designer with an idea of the content of the course. Then the instructional designer guides the professor, using questions, through the process of reorganizing the topics, beginning with the simplest to the hardest to learn and teach. Later the professor is asked to develop an electronic presentation for each topic. Frequently, these presentations were highly text oriented. The instructional designer in collaboration with the multimedia producer modifies the presentations. The professor is asked to develop a script for each slide. This is done in the annotations area of each slide. Then the slide area is used for images, graphics, and other visuals related to the content. Each presentation is then edited to have the same template, the same font type and size, and the same color scheme.

The professor receives the presentations and is instructed to review the new graphics and the script, and consider if more information should be added in each slide annotation area. The finished presentation is then used to create a video presentation. This video presentation, or learning object, is the center of each lesson. The professor is recorded in a video greeting the students and reading the objectives of each lesson. Then the professor is recorded narrating in audio the script for each slide. At the end of each video the professor appears again to summarize the main concepts discussed on each presentation. (example video: https://www.youtube.com/watch?v=jjj-FXJzc5w). Each presentation is made available, in video, in PDF format, and with the script, to enable its use by different learning styles. (example presentation: https://app.box.com/s/kqw093dnz4zwmjj5dcexefkbmdiumrr6).

For each video, i.e. lesson, the professor generates a short test and a discussion board with a rubric with the criteria for evaluation. These videos are published in the LMS (See Figure 2). A video introduction to the course (example video: https://www.youtube.com/watch?v=3b6EU3bX7do&feature=youtu.be) , a video tutorial on LMS navigation (example video: https://www.youtube.com/watch?v=zs-yfpfdPPU), and a presentation forum is added. Documentary type video was recorded for the lesson, which added variety to the content (example video: https://www.youtube.com/watch?v=wcfPpP_sgfc).

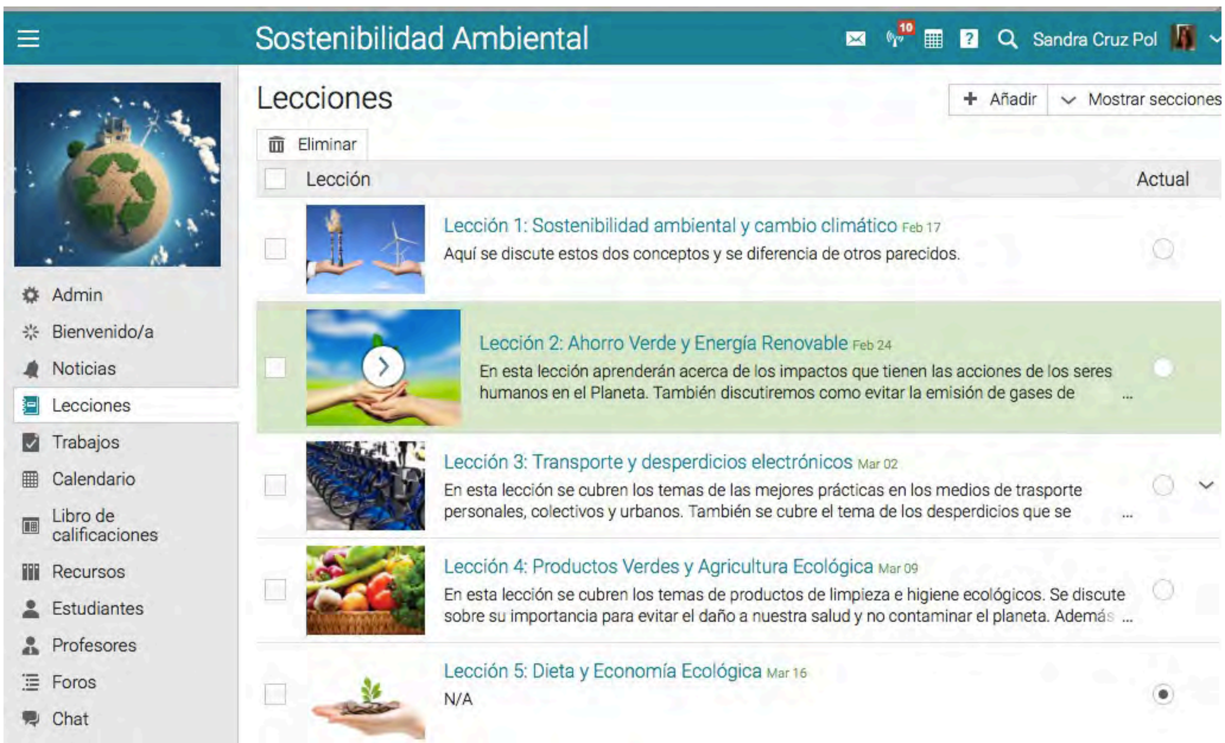

Figure 2 Partial view of the course (administered in Spanish) on the LMS platform

3. Data preparation

In this study, we used a literature review to develop the initial best practices for online course design and administration. The instrument used to collect data, was a survey developed using the Brain Targeted Teaching Model. The survey includes 24 quantitative single-selection questions and one open question. Some of the questions were directed to the design practices of the course and others to the course administration practices. The validity and reliability of the instrument was established in a previous administration.

4. Results

4.1 Qualitative Data: Perception of participants

Participants were a heterogeneous group of twenty-one (21) students from young adults to seniors; six men and fifteen women. Geographically, the students were distributed across the island of Puerto Rico, but two of them were from outside the island.

Immediately at the start of the course a student, apparently with some prior experience in online course wrote directly to the professor (ad verbum):

> *"Greetings!!! Excellent class, videos (are) very easy to understand and you (are) so active as a teacher on the platform (I've taken hybrid classes previously and you never see the teacher on the platform, only when handing in homeworks).*

This course has a duration of six weeks. On week number five, an online survey was made available to the participants, through the course LMS. One part of the instrument was an open statement that read: *Write any additional comments you want. Views and experiences in the course are welcome.* Here are some answers (ad verbum):

Student 1:
"I really like the course. I learned a lot and have incorporated best practices on my daily life thanks to this course. "

Student 2: *Excellent course format as well as videos. Very good work !!!!!!!*
"Excellent course, must give more courses related to this field."

Student 3:
"Excellent course, I love the topics and how they are organized."

Student 4:
"I decided to take this course because it has always interested me to learn how to live in harmony with the environment and thought that by taking this course learn about new ways of how to do it. However, this course has exceeded my expectations greatly, in a positive way, I am very glad I enrolled in this course because it has highly contributed in my personal and professional growth. The teacher has done an excellent job to teach and keep students interacting and commenting on the discussion forums of each lesson."

Student 5:
"It has been an excellent investment. I was completely satisfied and a pity that it does not last longer."

Student 6:
"Excellent training, valuable knowledge gained and group discussions gave us the opportunity to interact and know the feelings of the other peers and educational resource. Would participate in any such. Thank you!!"

4.2 Qualitative Data: Professor experiences
These statements were collected during the professor interview.

"*Despite having served as a teaching assistant for a long distance course offered at UMass over 20 years ago, and having loved the experience, I had never offered an online course myself. This is mainly because of the lack of infrastructure at UPR-Mayagüez to do so. The CREAD staff was crucial in making this possible. They provided the essential support and expertise necessary to realize a high quality online course. It would have been almost impossible to design such course independently and it would have taken too much of my time. The communication provided by the student forums, on the* *course platform, was crucial to obtaining feedback on how well the students were assimilating the course material and to identify and clear up any misconceptions. Moreover, it allowed me to motivate the students and create an ambiance of camaraderie. I feel I was able to get better acquainted with this group of students than students from face-to-face courses!"*

The asynchrony of the methodology was crucial for allowing students from the other parts of the world, as far as Hawaii, to participate. It granted the flexibility for the students to watch the videos and answer the assignments at their most convenient time. Multimedia aided in explaining clearly the ideas of the topics discussed in class and expanding related topics.

"*This experience changed the perspective I had about the teaching and learning processes. I am now an advocate of using this platform for many engineering courses. The platform is very efficient for increasing involvement/participation of the students especially for courses that are mostly concepts-oriented versus equations-oriented. Next semester I intend to use this platform for courses that are mostly mathematically/equations oriented*".

4.3 Quantitative Data

Some of the more important findings are that 66% of the participants perceived that in this online course more material was covered than in a traditional classroom course, 83% considered that in this online course there were more opportunities to demonstrate their acquired knowledge than in traditional face-to-face courses, 91% stated that the online course format facilitated the participation in it, 66% felt that the music in the background of the video do not affect negatively their concentration, 25% remarked that music actually help them to concentrate, 100% of participant asserted that the video production was excellent, and so was the course design, 91% recognized that the use of rubrics, in the tasks, is extremely important to reach their maximum execution, and 66% believed that the development of activities of discussion is extremely important to maintain their connection with the course.

4.4 Best practices

These are the best practices delineated as a result of the study now used to train the trainers and the faculty: 10 Best Practices: online course design on a Learning Management System

1. Organize your course by lessons
2. Include a description and objectives
3. Include the learning objects with the central concepts
4. Keep the learning objects brief and direct
5. Utilize consumption confirmation
6. Develop activities of application or discussion
7. Create forums as meeting points for students
8. Use rubrics and checklists
9. Include sample answers to the task
10. Include your course syllabus

20 Best Practices: For the Administration of an online course on a Learning Management System

1. Use the institutional email
2. Include a greeting and instructions for navigation
3. Present the syllabus and create a forum for discussion
4. Use a code of honor in the course
5. Request students to add their profile picture

6. Ask them to introduce themselves in a jovial and fun way
7. Create a diagnostics exam for each lesson
8. Use an image to identify your course and each of its lessons
9. Publish each lesson and task on the same day of the week, and ending the same
10. Use quizzes as a means of consumption confirmation
11. Use active tasks and request for all of their work to be public
12. Motivate the participation
13. Encourage peer communication
14. Ask how they are doing in the course
15. Establish your presence
16. Use periodical messages
17. Use one or two synchronized activities
18. Use positivism and enthusiasm
19. Turn on automatic notifications
20. Use an activity to close the course

5. Conclusions

This model covers the essential general areas, which deal with the design and administration of online courses. Adaptations were minimal. The comments participants made were significantly positive when they compared these courses with other courses they have taken previously. The process of developing continued education courses through this model increased the quality of the instructional and teaching materials as well as the quality of the activities, tasks, and quizzes. The application of the model and participants' reactions can be evidenced both visually and with documentation. The professor expressed positivism and interest in develop engineering online courses in the next semester.

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Is Blended Learning the Answer to Enhance Learning of Engineering Students?

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Abstract: This paper examines the incorporation of blended learning into an engineering course. Engineering is a very practical-based course, with many arguing that it is best taught in face-to-face mode. However, many students now expect a more flexible learning environment where they can tailor their studies around other commitments, and universities are supporting the move towards flexible learning. The integration of blended learning into engineering courses poses many challenges, including, but not limited to, balancing the practical component of the course with the face-to-face sessions, and still allowing for flexible delivery of the course. Ideally, blended learning incorporates the best of face-to-face and online delivery modes. This has proved to be a very delicate balance, and there are very few examples of universities that have achieved this balance for practical courses such as engineering. As universities move towards blended learning, a common approach is to reduce the number of contact hours, while increasing the amount of self-directed learning by students using online resources provided by the university. The concept behind this is for students to get most of their subject content online, and then interact and expand upon it in face-to-face sessions. In theory, this should increase the level of understanding of students, and allow for more efficient use of face-to-face sessions. One of the issues that will be explored in this paper is the balance between online and face-to-face learning, while maintaining the practicality of an engineering course.

Keywords: Engineering education, blended learning model, face-to-face delivery mode, flex mode, online learning

1. Introduction and Background

Traditionally, engineering has been taught through a mixture of face-to-face (F2F) theory classes supported by practical sessions where the theory is demonstrated and expanded upon. This mode, also known as chalk and talk mode, where the lecturers deliver the content of the subject in a classroom with students taking notes, has been criticised in recent years as lacking in efficacy (Becker and Watts, 1995; Sternberg, 1997; Axley and McMohan, 2006).

With the development of widespread communications and innovative technologies finding their way into the fields of education and training, online courses were promoted by universities around the world to provide both distance education and flexible learning options for students (Keegan, 1995; Monteiro and Morrison, 2014; Pillay and James, 2014). All the content and assessments are online, and online support is available to students without the need of F2F contact. However, this mode of education can cause a sense of learner anxiety, isolation, frustration and confusion for some students, resulting in a higher attrition rate (Piccoli et al., 2001; Laine, 2003).

Blended learning (BL) is a hybrid of F2F and online education (Graham, 2006; Smart and Cappel, 2006; Precel et al., 2009; Hwang and Francesco, 2010, Baeplera et al., 2014; Pillay and James, 2014). It can take several forms, and there are multiple definitions of what it entails. A flipped classroom, also known as an inverted classroom, is where students receive the majority of the content for a subject outside class (usually via readings or videos), and then interact and expand upon it in F2F sessions (Lage et al., 2000; Gannod et al., 2008; Bergmann and Sams, 2012). Often, the F2F sessions fall at the end of the week, to give students a chance to interact with online resources. Summative assessments, such as quizzes, are placed online to identify any issues or misunderstandings students are having with the online content, and these are then addressed in the F2F sessions. The flex model, which is similar to a flipped classroom, involves content being delivered by a combination of online and F2F modes (Graham, 2006, Staker and Horn, 2012). The distinguishing factor between the flex model and a flipped classroom model is the volume of material that is placed online, and the amount of student-driven study required to successfully complete the subject. The blended learning delivery mode, as defined at La Trobe University, requires that 25% of the student's workload be online-based (La Trobe University, 2015).

Worldwide, blended learning (BL) has been successfully implemented in many theory-based courses, including education, business and arts. Many universities offer the option of blended learning (Graham, 2006; Smart and Cappel, 2006; Precel et al., 2009; Hwang and Francesco, 2010, Pillay and James, 2014) or completing courses entirely online (Keegan, 1995; Monteiro and Morrison, 2014; Pillay and James, 2014). Engineering courses are now facing the challenge of incorporating blended learning into what is essentially a practical-based course (Lane, 2003; Precel et al., 2009, Pillay and James, 2014). At La Trobe University, blended learning has been included in several subjects of various courses. However, this paper describes how blended learning has been incorporated in a number of subjects of the Civil Engineering course.

Civil Engineering has a long tradition at La Trobe University (LTU), and it was originally offered at the Bendigo School of Mines (at diploma level) in 1873. This tradition has continued with the Civil Engineering course offered by LTU, initially at the Bendigo campus and now at the Bundoora campus since 2014. The course currently offered at LTU is typical of an Australian full-time undergraduate Civil Engineering course of four-years duration. The curriculum has been changed several times since its inception to incorporate new trends and approaches in professional practice and engineering education, with the most recent changes being made in 2015. Graduates are awarded a Bachelor in Engineering (Honours) – Civil Engineering on completion of the course. Blended learning has been incorporated in several subjects in the course, including *Physics*, *Engineering Design and Problems Solving*, *Engineering CAD*, *Mechanics of Solids*, *Introduction to Spatial Sciences* and *Surveying*. While the ways in which blended learning has been generally incorporated into subjects will be discussed, the paper will primarily focus on the last two subjects.

2. Critical Review of Blended Learning in the Civil Engineering Course at LTU

2.1 General

It is agreed that blended learning involves more than just placing the subject's lectures online, expecting students to familiarise themselves with the content prior to coming to class, and then re-visiting the same material in class (Lage et al., 2000; Graham, 2006; Smart and Cappel, 2006; Gannod et al., 2008; Precel et al., 2009; Hwang and Francesco, 2010; Staker and Horn, 2012; Baeplera et al., 2014; Pillay and James, 2014). One of the biggest challenges for educators is constructing a subject that effectively blends online and F2F content, fully engages students, and is "learning centred, content centred, community centred and assessment centred" (Anderson, 2004). Balancing the online content with the F2F sessions, and maximising the potential of both is a difficult task for any subject. It becomes especially difficult in practical courses such as engineering.

2.2 Critical review of implementing blended learning

Physics has moved towards a full flipped classroom model, and the subject's content is provided online. Students are given a variety of readings to review and videos to watch, and are also required to complete online quizzes based on the online material. The material is reviewed in F2F sessions at the end of the week, and any misunderstandings or difficulties are resolved. According to verbal feedback, students found that having the F2F sessions after they have studied the online content was confusing. The common consensus was that having a F2F session at the beginning of the week and one at the end of the week would better align the online content with the F2F sessions. It was also found that the improved results in the subject are more of a reflection in the change in assessment of the subject, rather than the change in the delivery mode. The subject moved from an exam with a 60% weighting at the conclusion of the semester to two tests undertaken at half-semester intervals, and a final exam with a weighting of only 40%.

Mechanics of Solids has also moved towards blended learning using the flex model. Students are required to watch videos and work through online examples on a weekly basis. Self-assessment questions are provided, so that students can check their level of understanding of the content. Verbal feedback from students indicates that they find that the worked examples and self-assessment questions increase their level of understanding of the subject content. However, they state that the videos are long and 'boring', and that they only watch them when experiencing difficulty in working through the online examples and questions. Hence, this form of blended learning or flex mode delivery has resulted in a mixed level of success. In addition, the final grades of the subject do not reflect a change in the delivery of the subject.

For both of these subjects, feedback from students reflected a strong dislike of the blended learning concept, with the most common comment being along the lines of 'If I wanted to study online, I would have chosen an online course. I came to university for the face to face contact, and to be taught by professionals in their chosen fields.'

3. Case Study – Introduction of BL to Spatial Sciences

3.1 Overview of subject delivery in F2F mode

Introduction to Spatial Sciences (ISS) is the first of the two surveying subjects that engineering students encounter in their course, and it is the prerequisite for *Surveying*. Blended learning in the form of the flex mode delivery has been incorporated into the delivery of this subject since 2014. The content of this subject includes datums, levelling, traversing, GIS and remote sensing. The delivery method is a combination of desktop activities and infield practical exercises. Prior to the incorporation of blended learning, the subject had five hours of F2F contact per week over a 13 week semester. The structure and assessment of the subject are presented in Table 1.

3.2 Overview of subject delivery in flex mode

With the move towards flex mode delivery in 2014, the F2F contact hours were reduced to 4 hours, and Table 2 presents the revised structure and assessment for the subject. In addition, LTU adopted a 12 week semester in 2014.

The two academics involved in delivering the subject found that it ran smoothly with the four-hour workshop. The incorporation of the online activities and content led to the majority of students coming prepared to the workshop sessions. Verbal feedback from students indicated that, while they found the content interesting, they felt that their workload was high due to the online work they were required to complete. The overall results for 2013, 2014 and 2015 are presented in Figure 1, where 2013 is prior to the introduction of blended learning, and 2014 and 2015 are the results after blended learning was used. The results do not show a direct correlation between the grades and the introduction of blended learning. However, it could be argued, based on the improvement from 2014 to 2015, that the results will further improve in the future.

Table 1 – *Introduction to Spatial Sciences* – structure and assessment

Mode of Delivery	Hours/Week	Comments
Lecture	2	Traditional lecture format.
Practical	3	A combination of four infield practical sessions using common surveying equipment, such as automatic levels, total station and GPS units, and desktop-based activities involving GIS software and remote sensing technology.
Assessment	Weighting	Comments
Assignments	45%	4 x assessments: A combination of both written and calculation tasks. These are unevenly weighted, with the weighting based on the level of difficulty, and the expected workload of the students.
Practical Reports	30%	3 x practical assessments: Assessed by written reports that are based on the results of the practical exercises. These are unevenly weighted, with the weighting based on the level of difficulty of the practical task and report.
Exam	25%	Two-hour exam.

Table 2 – *Introduction to Spatial Sciences* – revised structure and assessment

Mode of Delivery	Hours/Week	Comments
Workshop Session	4	4 hours of flexible teaching that incorporates all practical and desktop activities, and any additional content that has not been provided online.
Online Content	1	Students are expected to spend approximately one hour per week interacting with the online content.
Assessment	Weighting	Comments
Assignments	20%	2 x written assessments based on the desktop activities.
Online Activities	15%	Transitional tasks related to the topics that provide the basis for the F2F workshop sessions.
Application tasks	40%	A combination of written and calculation tasks arising from the workshop activities, including both practical and desktop activities.
Exam	25%	Two-hour exam.

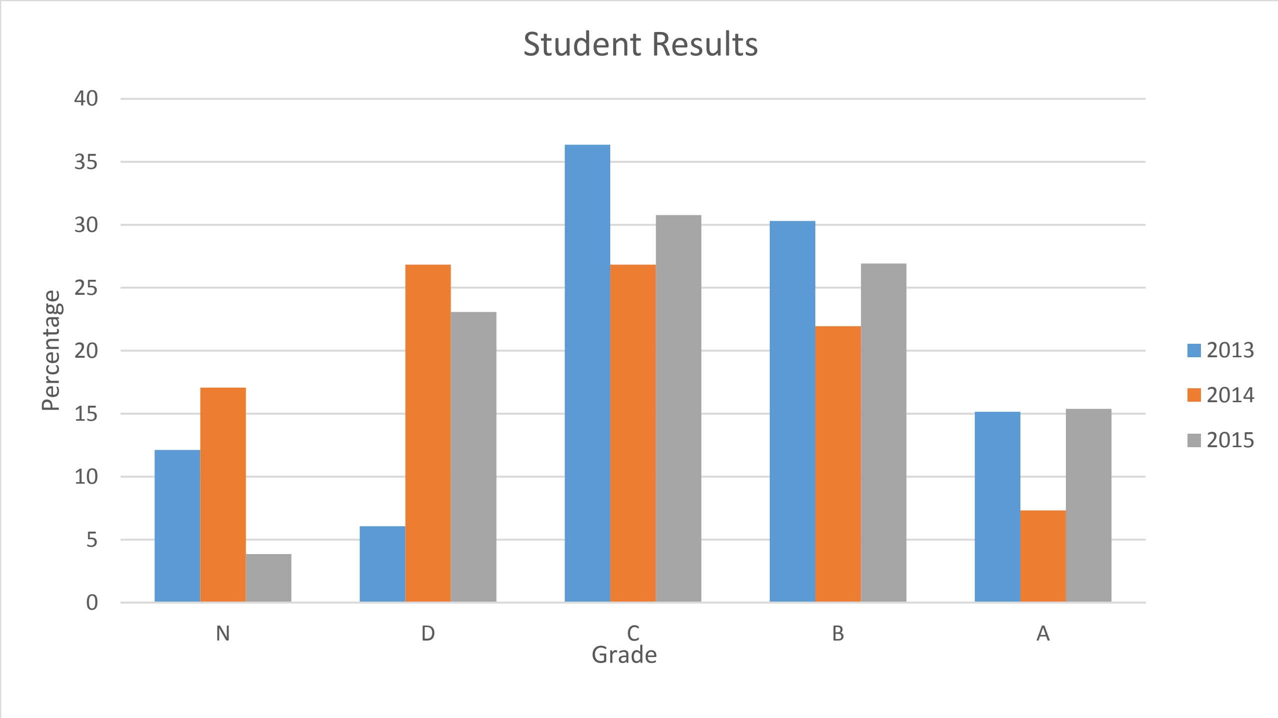

Figure 1. Grades before and after the introduction of blended learning

4. Case Study – Introduction of BL to Surveying

4.1 Overview of subject delivery in F2F mode

Surveying is a subject that is taught to second-year Civil Engineering students. The content of this subject includes:

- Resections – determination of your position based on measurements to the location of two or more known points of interest.
- Area and volume calculations.
- Curves – the design and layout of horizontal and vertical curves in road design.
- Feature surveying – where all the relevant details within a specified area are recorded for a specific purpose. An example is recording the location of all underground services within a designated site, and detailing this on a plan for future reference.

Due to the practical nature of surveying, the assessment is weighted heavily towards the practical component, with 40% of the final mark dedicated to performance in the practical sessions and the associated reports. The structure and assessment of the subject prior to the incorporation of flex mode delivery is shown in Table 3. The subject ran over a 13 week semester.

4.2 Overview of subject delivery in flex mode

The structure of the subject was changed in 2014 with the introduction of blended learning and a 12-week semester. The new structure of the subject involves removing the tutorial component of the subject, and reinforcing the requirement of the completion of online work prior to coming to the F2F sessions, as was done in ISS. The online tasks were designed such that the completed task would be used in the F2F session, and they were also reinforced and used in the practical sessions. The overall assessment of the subject remained the same. However, the marks allocated to the assignments were broken down into two categories. Half the marks were allocated to the completion and submission of online tasks, and these tasks needed to be completed prior to coming to the F2F sessions. The remaining marks were allocated to online quizzes that were used for both formative and summative assessments. The F2F sessions also moved away from being traditional lectures towards being interactive workshop sessions. Details of the revised structure and assessment are given in Table 4.

Table 3 – *Surveying* – structure and assessment

Mode of Delivery	Hours/Week	Comments
Lecture	2	Traditional lecture format.
Tutorial	1	Interactive tutorial session.
Practical	3	Infield practical sessions involving the use of common surveying equipment.
Assessment	**Weighting**	**Comments**
Assignments	20%	2 x calculation-based assessments.
Practical Reports	40%	4 x practical assignments: Assessed by written reports. These are unevenly weighted, with the weighting based on the level of difficulty of the practical task.
Exam	40%	Three-hour open book exam.

Table 4 – *Surveying* – revised structure and assessment

Mode of Delivery	Hours/Week	Comments
Lecture/workshop	2	Interactive workshop session.
Practical sessions	3	Infield practical sessions.
Online Transitional Tasks	1-2	To be completed prior to F2F sessions.
Assessment	**Weighting**	**Comments**
Practical Reports	40%	4 x reports based on the results of practical sessions. These are unevenly weighted based on the level of difficulty and the expected input from students.
Online Transitional Tasks	10%	Tasks to be completed prior to attending F2F sessions.
Online Assignments	10%	Calculation-based assessments in the form of online quizzes.
Exam	40%	Three-hour open book exam.

There was a 23% increase in the final marks above 80%, which was accompanied by a subsequent decrease in the percentage of students with marks between 60% and 79%, after the introduction of blended learning. However, it should be noted that the number of students varied between cohorts, and that this was the first time the subject has run in the revised format. Hence, no conclusions can be drawn from this alone. It was observed that students were better prepared for classes, were more engaged with the content, and had a better understanding of the subject. However, verbal feedback from students indicated that they felt that their overall workload had increased significantly by having to undertake the extra online activities, although they saw the relevance and linkage between the tasks, the F2F sessions and the practicals.

5. Conclusions

In the subjects in the Civil Engineering course at LTU where blended learning has been used, there has been no noticeable difference in the overall student grades. While academic staff observed positive effects from incorporating blended learning concepts into the delivery of subjects, student feedback was less positive. Students felt that their workload has increased significantly with the introduction of blended learning. This response is likely to change over the coming years as high schools and universities move towards a flexible learning environment, and blended learning is the accepted norm rather than a new concept. From the results of the subjects where blended learning has been incorporated in various forms, there has been no evidence to suggest that the incorporation of blended learning into the delivery of engineering subjects enhances the learning of the students.

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The Perception of Students towards Engineering Programs at University of Malaya

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Abstract: This study focused on the factors affecting enrolment of students for various engineering programs in University of Malaya, challenges facing Engineering Education, effects of the problem and remedies to address the problems. A total number of 406 samples were drawn from University of Malaya. Instruments used in the collection of data were questionnaires, interviews, and analysis of documents. The study revealed that low participation of students in engineering programs in University of Malaya was influenced by lack of interest, disregard for students who pursue engineering programs and lack of attention to engineering vocational education in the country. Conclusion drawn was that, engineering education requires more attention and must be organised properly to attract more students especially in the engineering institutions.

Keywords: Perception, Interest, Engineering programs, University of Malaya, students

1. Introduction

The importance of science and engineering education is underscored by the fact that it provides solutions to human resource problems and also helps to find solutions to needs of society [1]. The manpower structure of every nation demands a large stock of trained workforce including skilled labour, craftsmen, technicians, and engineers who together work to provide the infrastructural needs required for national development. It is the trained manpower that provides the workforce for infrastructural development and also the needed services to achieve economic development and stability. There is less dependence on government for employment and funding in recent times because trainees who have the necessary entrepreneurial skills create jobs and employ people to work in industries [2]. Engineering education is therefore an investment with very high returns. It helps to solve unemployment problems when more jobs are created by trained manpower. Another important role of science and engineering education is the opportunity to produce researchers to spearhead inventions, find solutions to problems and adopt foreign technology for local use [3].

Understanding the importance of engineering education, University of Malaya (UM) is one of research universities in Malaysia is offering engineering programs at undergraduate and postgraduate level. The programs are conducted by the Faculty of Engineering which has been established since 1950. Faculty of Engineering, University of Malaya has set out a long term objective to develop quality engineers after graduation. This faculty consist of five departments such as Department of Civil Engineering, Department of Electrical Engineering, Department of Chemical Engineering, Department of Biomedical Engineering and Department of Mechanical Engineering. Overall, 12 undergraduate and 11 postgraduate engineering programs are offered by the Faculty of Engineering, University of Malaya. [4]

Participation of students in some of the engineering Programs in Faculty of Engineering, University of Malaya is very low in recent times [5]. The problem of low participation of students in engineering Programs in Faculty of Engineering, University of Malaya need prompt attention in order to save the affected departments from collapse. It is therefore necessary to identify the factors that are responsible for the low participation of students in engineering Programs at the Faculty of Engineering, University of Malaya.

This study was therefore designed to explore the factors responsible for the low participation of students in engineering Programs offered at the Faculty of Engineering, University of Malaya. It was intended to find out what conditions need to be created to encourage higher participation levels. Attempts were also made to examine the challenges facing the Faculty of Engineering, University of Malaya in recruiting eligible candidates from the various engineering institutes and second cycle institutions to pursue engineering Programs. The rest of the paper is organized in the following manner. Section II discusses the methodology for conducting the study such as population, sample, and sampling procedure, research design, research instruments, administration of instruments, problems encountered in the process of collecting data and the data analysis procedure. Section III focuses on the presentation, analysis and discussion of the data gathered from the field while section IV provides a summary of the study and also discusses the findings of the study. Finally, conclusions and recommendations of the study are drawn in section V.

2. Method

The methodology for carrying out the investigation is discussed in this section. The purpose of this study is to investigate factors influencing low participation of students in engineering Programs at the Faculty of Engineering, University of Malaya. Self-developed questionnaires have been distributed among undergraduate students in the Faculty of Engineering, University of Malaya. The questionnaires is divided into seven parts and the areas covered are;

a. Demographic data
b. Importance of the Engineering Programs.
c. Challenges facing the Engineering Programs in Malaysia.
d. Factors influencing low participation in Engineering Programs.
e. Effect of low participation of the youth in Engineering Programs.
f. Public perception of Engineering Programs.
g. Interventions to improve participation in Engineering Programs.

The sample is 406 undergraduate students which included 121 first year students, 83 second and third year students and 202 final year students. All of them are undergraduate students who are still undergoing engineering programs at the Faculty of Engineering, University of Malaya. The study was a descriptive one, so qualitative analysis involving frequencies, percentage mean and mode in the analysis of the collected data are used. Scores were obtained for the various items in each section, tallied and percentages were calculated to show the extent to which respondents agree or disagree to the various questionnaire items.

3. Results and Discussion

The analysis of the results of this study dwells on demographic data, importance of the engineering programs, challenges facing the engineering programs in Malaysia, factors influencing low participation in engineering programs, effect of low participation of the youth in engineering programs, public perception of engineering programs and interventions to improve participation in engineering programs.

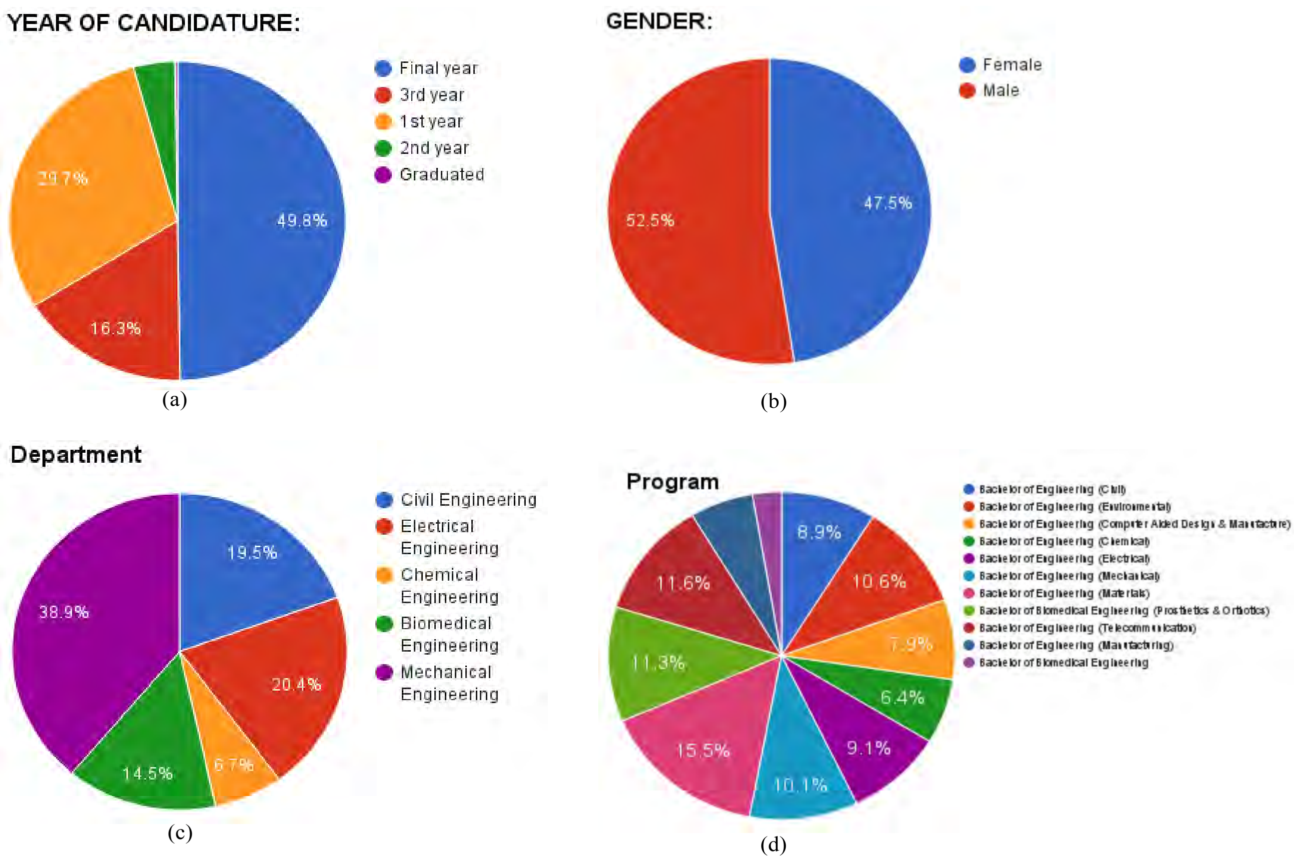


Fig. 1. (a) year of candidature, (b) gender, (c) department and (d) programs of respondents.

3.1 Demographic Data

The analysis of data on year of candidature and sex, department and programs of respondents are presented in Fig. 1 which revealed that there was high final year student involvement in the research. Out of a total of 406 respondents, 49.8% were final year, 29.7% were first year, 16.3% were third year, and rest of them are second year students. It was found out that almost 52.5% respondents were male student. The Fig. 1 also shows that almost 38.9% respondents were from mechanical engineering department, 20.4% were from electrical, 19.5% were from civil engineering, 14.5% were from biomedical engineering and 6.7% were from chemical engineering department. The percentage of respondents from different engineering programs are also mention in Fig. 1.

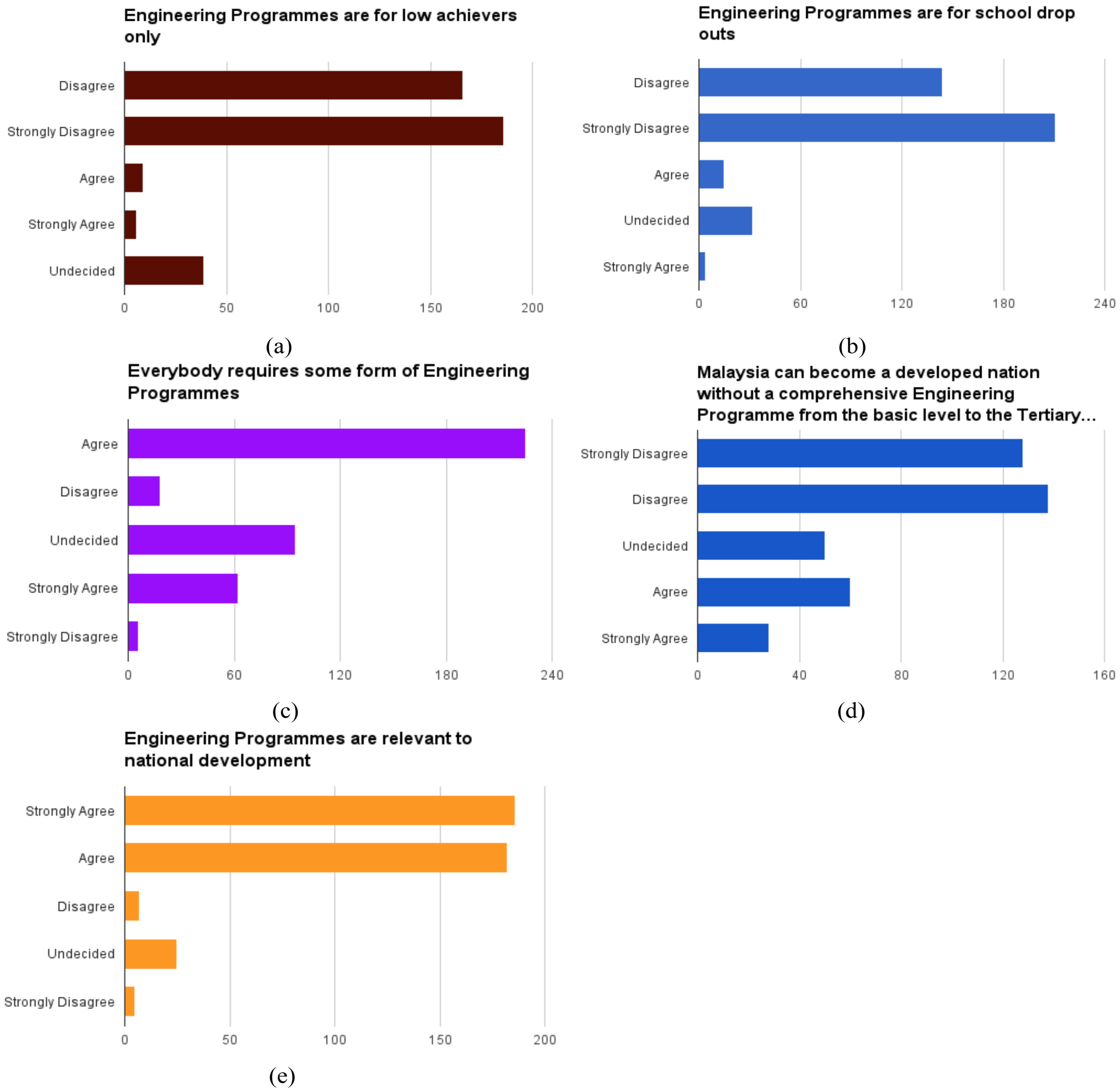


Fig. 2. Importance of the engineering education and training programs.

3.2 Importance of the Engineering Education and Training Programs

Figure 2 shows the results obtained to show the opinion of respondents on which people should participate in engineering programs. It also shows whether there are benefits to be derived from engineering education and training by a nation. It provides answers to research question 1. As shown in Figure 2 (a), most of the respondents strongly disagreed that engineering programs are designed for only low achievers or school drop outs. More than 200 respondents out of 406 total respondents agreed that everybody requires some form of engineering education and training since Malaysia cannot become a developed nation without a comprehensive engineering program from the basic level to the tertiary level. Most of them strongly agreed that engineering programs are relevant to national development. The responses from all the respondents clearly indicate that engineering education and training are worthwhile for the industrial development and the economic and social progress of Malaysia. It is critical to give engineering education the necessary attention and support to promote total development of the country.

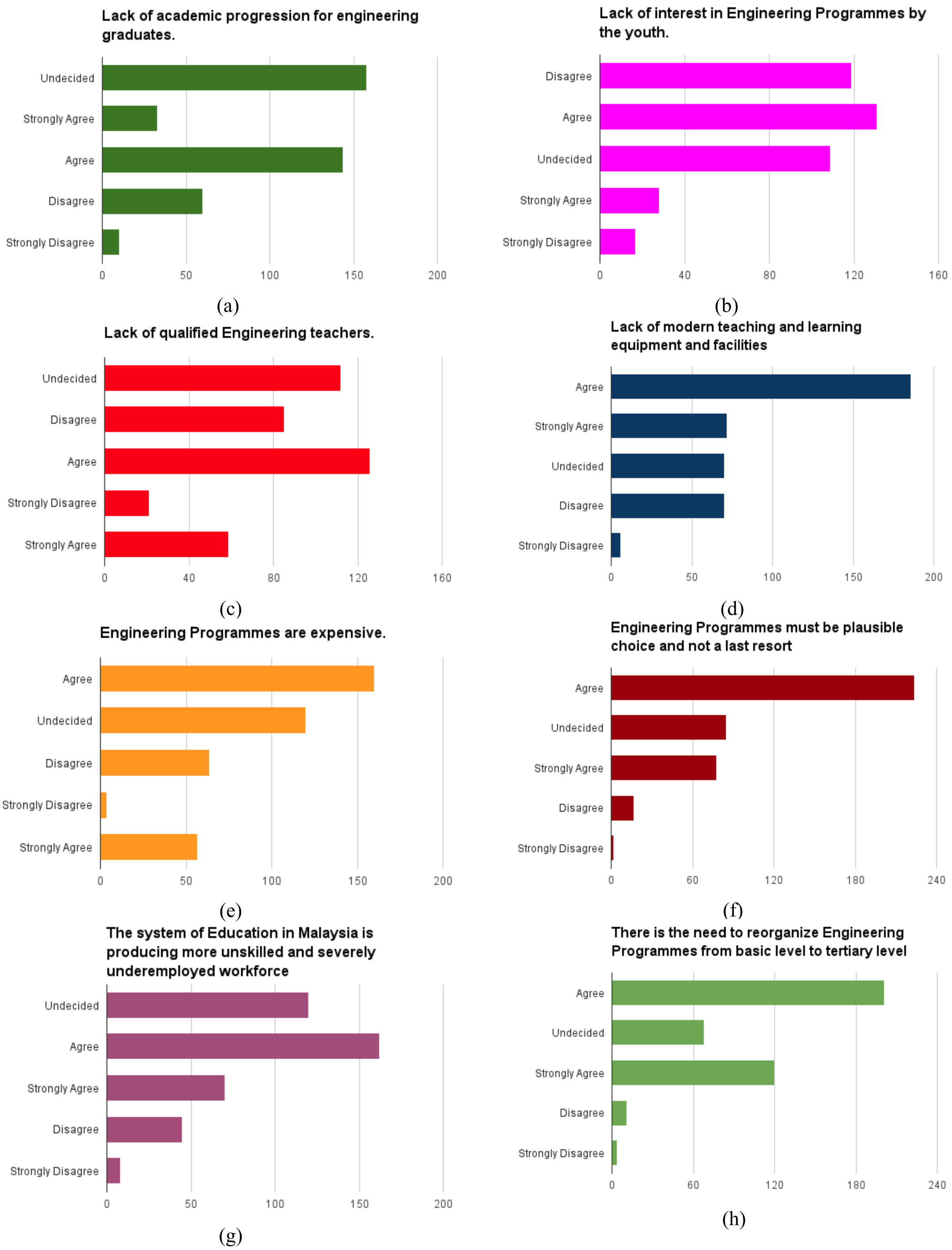


Fig. 3. Challenges facing the engineering programs in Malaysia.

3.3 Challenges facing the Engineering Programs in Malaysia

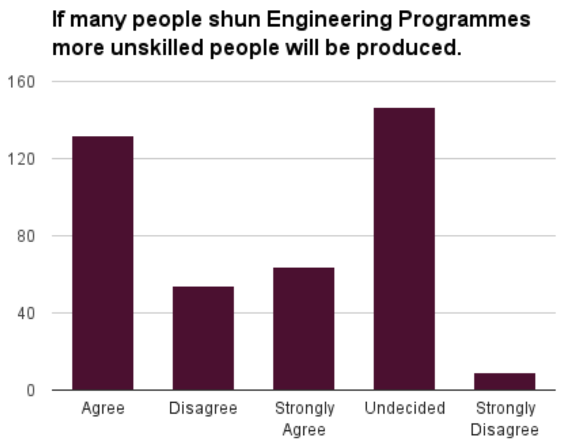
This section provides answers to research question based on challenges facing the engineering programs in Malaysia. Figure 3 shows data on challenges that prevent the development of engineering programs. Although around 140 respondents out of 406 agreed that there is lack of academic progression for engineering graduates but the majority portion of students were not confirming about that matter. The responses obtained refer to an incomplete progression of the engineering graduate to the highest level of the educational system in Malaysia. Lack of interest in engineering programs by the youth was cited by 130 of respondents. This implies that students are not attracted to engineering programs, a problem that could be attributed to purported lack of prospects for engineering school graduates and lack of encouragement from people. It could also be attributed to lack of attention given to engineering programs.

These might be the reasons why students show very low interest in engineering Programs. However, most of the respondents (130) also agreed that there is lack of qualified engineering teachers in the Faculty of Engineering. A popular concern over the absence of modern teaching and learning equipment and facilities was shown by tutors. This is a genuine concern that could affect participation in engineering programs in the faculty. Students show deeper understanding of theory if they get the opportunity to develop the needed skills by using tools and equipment and machines effectively. Almost 160 respondents conceded that running of engineering programs is expensive. However, this should not scare stakeholders because the investment returns in human resource could be huge and beneficial to the nation. The need to make engineering programs a plausible choice but not a last resort was accepted by majority of respondents, since it could help to improve participation of students in engineering programs. Majority portion of respondents also agree that the system of education in Malaysia is producing more unskilled and severely underemployed workforce. They also agreed that it is time to reorganize the engineering education and training from the basic level to the tertiary level. This is critical because a well-defined and structured engineering program has contributed greatly to the development of great nations in Europe, America and Australia.

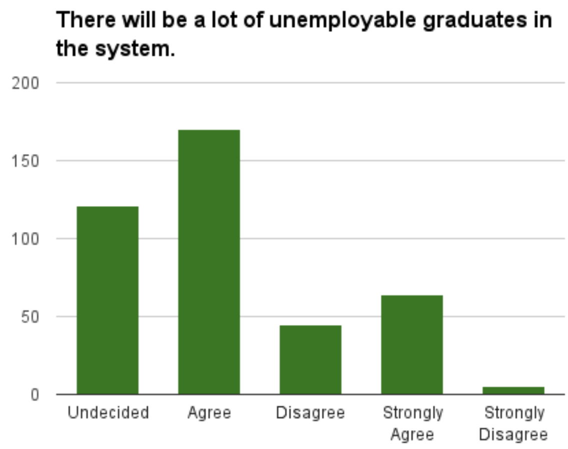
3.3 Factors influencing low participation in Engineering Programs

This section constitutes answers to research question regarding the factors influencing low participation in engineering programs. As presented in Figure 4, almost 38.2% of respondents agreed that lack of engineering institutes to serve as breeding grounds for University of Malaya is a factor influencing the low patronage of engineering programs. This revelation has seriously affected participation in engineering programs because students would be attracted to engineering programs if they already have basic knowledge in the area from Secondary Engineering School or engineering institutes. The absence of engineering institutes in the Region has seriously affected enrolment in the engineering Programs at the University of Malaya.

Forty-three (43%) of respondents also agreed that lack of boarding and lodging facilities for young engineering students is also a factor militating against the patronage of engineering programs in University of Malaya. It is known that students in some of the secondary engineering Institutes enjoy boarding and lodging under the strict supervision of their teachers. However at the University of Malaya the hostel system and level of supervision is minimal. This might have discouraged parents and guardians from sending their children to pursue engineering programs at the University of Malaya.



(a)



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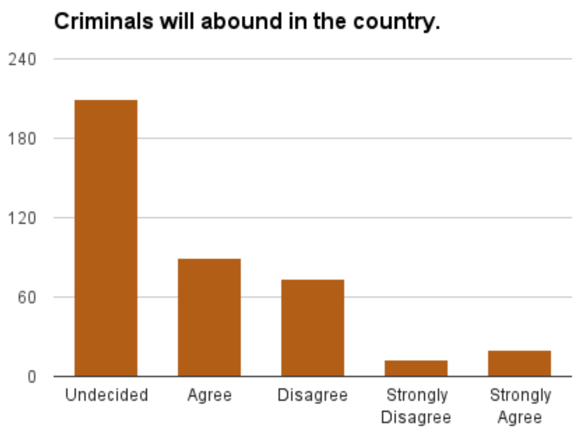

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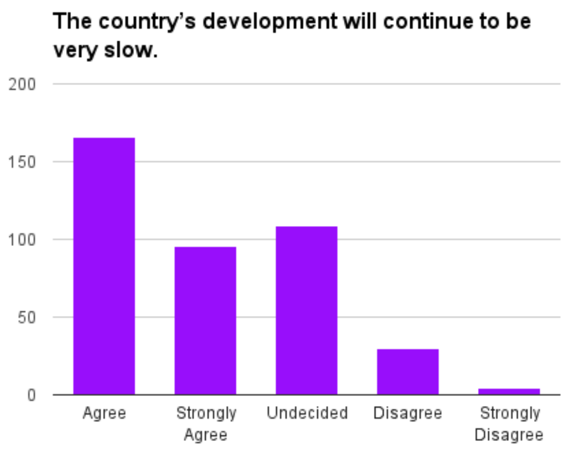

(d)

Fig. 5. Effect of low participation of the youth in Engineering Programs.

Majority of the respondents (170) confirmed that it is not easy to get employment after graduation. This might be as a result of the type of employment the respondents may be referring to. A student who has been trained in an engineering program should not work in an office for administrators. The emphasis on skills acquisition could only be useful if students could apply what has been imparted to them.

3.4 Public perception of Engineering Programs

This section provides answers to research question regarding the public perception towards engineering education and their level of involvement in engineering education. As shown in Fig. 6, majority of respondents (220 out of 400) agreed that engineering programs as popular. Similarly, a greater number of respondents (200) think that engineering programs is a very high quality education. Moreover, the majority of respondents did not consider engineering education a preserve for low achievers.

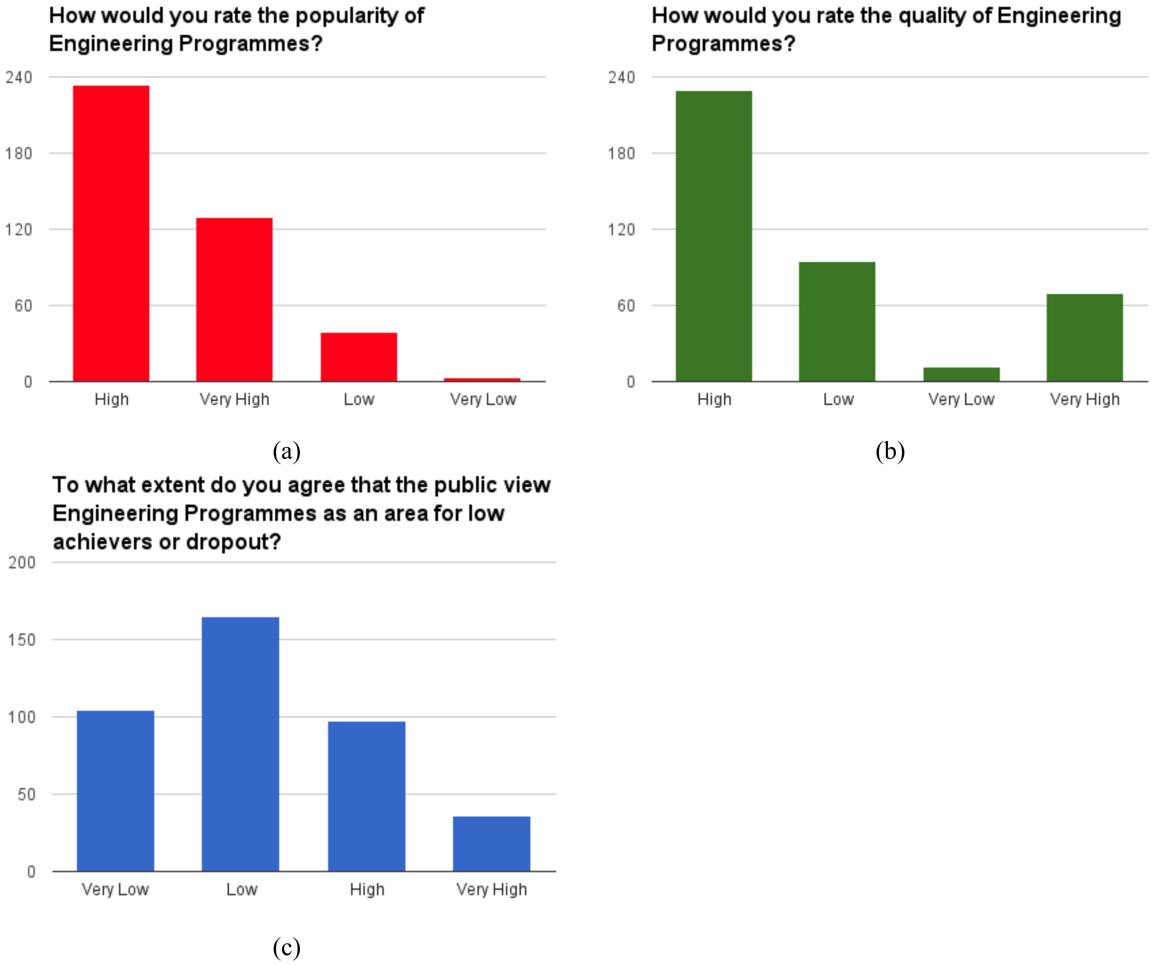

Fig. 6. Public perception of Engineering Programs.

3.5 Measures to be taken to improve enrolment of students in Engineering Programs at the University of Malaya

This section provides answers to research question that what measures should be taken to improve the enrolment in of students in engineering programs at the University of Malaya. With regard to the peculiar institutional enrolment problems at the Faculty of Engineering in University of Malaya measures proposed by respondents for improving the situation are stated in following section. Almost all the respondents agreed to the fact that there is the need to improve upon enrolment in engineering programmes in University of Malaya by embarking on recruitment programmes through the media and touring of the Engineering Institutes and the Secondary Engineering schools. Students in Secondary Engineering Schools in the region may not be aware that their graduates could pursue further studies at the non-tertiary level in the University of Malaya.

A special collaborative programme between the Engineering Institutes, Secondary Engineering Schools and the Polytechnics could be established to ensure constant supply of students in engineering programme at the University. Respondents unanimously agreed that brilliant students should enjoy scholarships and all others must enjoy some form of support. There is emphasis on support for students who pursue engineering programmes. Funding engineering programmes is expensive and could scare parents and guardians from sending their children or wards to pursue such programmes. The introduction of scholarships and support could spur them on to allow them to participate in engineering programmes. It will make such programmes attractive to students. All the respondents recommended industrial attachment and the creation of jobs for students as measures to improve enrolment in engineering programmes. Industrial attachment and creation of jobs for Engineering school' graduates should feature prominently in the Nation's developmental agenda. Students will benefit by developing more hands on skills in industry and will be engaged in job creation. This could motivate other students to chart the same course to make a living. The benefits to be derived could be huge since more jobs would mean a demand for more Engineering School graduates.

4. Summary of Key Findings

The following are the main findings of the study;

4.1 The perception that engineering programmes are preserved for school dropouts and low achievers is wrong and could not be a factor influencing low participation of students in some non-tertiary engineering programmes in University of Malaya. It became clear that engineering education should be embraced by all stakeholders.

4.2 Tutors and students attributed the low participation in engineering programmes in University of Malaya to:

a) Lack of academic progression of students who do not have basic entry requirements in core subjects like English language, mathematics and integrated science. The core subjects do not form part of the final examinations organized by the engineering examinations unit for non-tertiary programmes.
b) Low interest in engineering programmes as a result of misconceptions about engineering programmes and poor public image of students who pursue non-tertiary engineering programmes. They believe it is not lucrative and has fewer prospects.
c) The absence of engineering institutes/secondary engineering schools in the University Region to produce students to pursue engineering programmes in the University of Malaya.
d) Obsolete and malfunctioning machines and lack of learning equipment in the affected departments in University of Malaya.
e) Poor parental support and lack of financial assistance to students in engineering programmes as a result of the expensive nature of the programme.

4.3 The deficiencies in the education system according to respondents has resulted in the neglect of engineering and led to:

a) The production of grimmer school graduates than science and engineering graduates.
b) Production of unskilled and underemployed youth.
c) Wasted human resources who are only interested in criminal activities.

4.4 Tutors, students and apprentices believe the following measures among others will improve participation of students in engineering programmes at the University of Malaya:

a) Introduction of practical training in pre-engineering skills at the J.H.S level to make it more meaningful and develop interest in the engineering programmes at an early stage.
b) Encourage students to pursue engineering programmes at higher level by reviewing

syllabus at lower level and also make core subjects; English language, Mathematics and Science examinable.

c) Restructure the education system to emphasize engineering programs and make it prioritized area of Government Education policy.
d) Provision of resources and support for students in engineering institutes, secondary engineering schools and the polytechnics.
e) Introduction of a uniform programme in engineering training toward, the award of a more recognized qualification.
f) Institution of an award scheme for brilliant technologists.
g) A recruitment drive in secondary engineering schools and engineering institutes to be pursued.
h) Integration of apprenticeship programmes into the mainstream of the education system.
i) Stakeholders fund should be introduced to support engineering training.
j) Introduction of internship programmes in industry and garages for trainees.
k) Introduction of technology fairs to boost interest in engineering programs.
l) Introduction of community sponsorship scheme.

4.5 The Vice Chancellor, Deans, Departmental Heads and lecturers of University of Malaya recognise the importance of engineering programmes to national development and observed that it has not been given the needed attention it deserves. They mentioned the following benefits of engineering programmes if organised properly:-

a) Engineering programmes produce more refined middle level manpower for industry and construction.
b) The youth is equipped with employable skills and make them useful citizens of society.
c) The youth is also endowed with engineering knowledge and entrepreneurial skills to create jobs.

4.6 There is a general acceptance by respondents that low participation of students in engineering programmes has been noted as a problem in almost all the Universities in Malaysia.

4.7 Lack of boarding and lodging facilities have been mentioned as issues militating against participation in non-tertiary engineering programmes.

4.8 Apprentices mentioned lack of support while on training and lack of opportunity to progress academically.

4.9 There is a general concern among tutors and students that the negative perception by the public about engineering education makes it unpopular to students.

5. Conclusion

The following conclusions can be drawn from the findings stated above though there were slight differences in the responses and other factors that might have influenced the findings. It is observed from the study that many people recognize the importance of engineering education to the development of the country. The implication is that:

i) Engineering education offer young men and women the needed engineering and professional skills for socio-economic development of the country.
ii) The engineering education offers people self-employment.
iii) It is essentially meant for the youth who complete the J.S.S and S.S.S and want to acquire engineering skills for employment in industry and the world of work.

Students from the J.H.S and S.H.S show little or no interest in engineering programmes but are later compelled to pursue it as a last resort when all hopes in entering the university fail.

Another observation from the findings is the general disregard in engineering programmes by students and lack of interest by the public in engineering education as a result of negative public perception. People believe that there are no better prospects for engineering school graduates. The observation suggests that students have not been encouraged to pursue engineering programmes due to lack of attention to engineering education by Government and policy makers.

It is also observed from the study's findings that it is expensive to pursue engineering education as a result of cost of educational materials, tools and equipment. While students who pursue business programmes do not require additional training cost and must have been a major factor for the high patronage, students in engineering programmes pay for cost of training materials. The observation suggests that cost of training materials and other maintenance expenses should be supported by a special engineering training fund.

A further observation from the study's findings is the undefined structure of engineering programs in the education system in Malaysia. Engineering Education has not been structured properly to fit into the current education system hence the low patronage in engineering programmes. The need to restructure the education system is now. It should lay emphasis on engineering education since the total development of the country is not only hinged on liberal education but also science and engineering education.

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Engineering a Novel Anatomical Foot Model for Anatomy Education

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Abstract: Using 3D printing to fabricate a foot model with softness of skin – shore OO hardness, to enhance palpation skills in anatomy education. Fabrication of the foot model involved the combination of 3D printing and casting techniques. The bone structure was 3D printed on a commercial 3D polyjet printer, with rods inserted between the bones on a .STL data file to hold the bones together. A commercial Fused Deposition Modelling (FDM) machine was used to fabricate the mould for silicon casting to replicate the soft tissues. Casting allowed the soft tissue replication to be transparent to facilitate visualisation of the 3D bone structure. The surface roughness (Ra) of the mould improved from 0.209 micrometre in average to 0.04602 micrometre by vapour polishing before silicon casting the soft tissue part. A functional foot model was fabricated using a combination of 3D printing and silicon casting. This model serves as a good translational tool so that students understand the functionality in clinical reasoning. Low cost fabrication of body parts will enhance anatomy education. The part fabricated is superior to older teaching resources as these models allow for visualisation of structures not visible in a normal human foot, inexpensive, scalable, and are easy to mass-produce in any part of the world. Thus functional 3D models are a viable resource to stimulate palpation skills for increased engagement and the ability to practice and revisit the information for anatomy students.

Keywords: Anatomy, medical, engineering, CAD, 3D printing, additive manufacturing

1. Introduction

3D printing (3DP), additive manufacturing (AM) or rapid prototyping (RP) takes digital input in the form of Computer Aided Design (CAD) model and creates solid, three dimensional parts through an additive, layer by layer process. This process is also referred to as layered manufacturing, solid free form depending on the method used.

A number of established manufacturing techniques and many experimental technologies in 3DP exist. Each technology has its own limitations and application in producing prototype models. Some well know techniques are Fused Deposition Modelling (FDM), Laminated Object Manufacturing (LOM), Selective Laser Sintering (SLS), Stereolithography (SLA) and Inkjet Printing. These techniques have been discussed extensively in academic publications Rooks , (2002), Rengier , et al, (2010) and Gibson et al (2010).

3D printing applications in medicine are classified into three categories; firstly for biological tissue engineering, secondly for making implantable prosthesis and thirdly for making surgical planning models and teaching aids as discussed in Rengier F. , et al, (2010) and Gibson et al, (2010). The ability to produce physical models from CT and or MRI scan images has tremendous usefulness in education for health and medical professionals as well as patients. For example 3D printed models are now used for preoperative planning and procedure rehearsals before a procedure is carried out in real life as discussed by Costello J. P. et al, (2014). However, to further enhance translation of theory into clinical practice, anatomical 3D print models would benefit from the ability to replicate tissue pliability so that tissues can be palpated and readily identified. Different levels of transparency in the other layer of tissues between models could also assist learners to visualise as well as kinaesthetically identify different anatomical features. The purpose of this paper is to describe the process undertaken to fabricate a 3D print foot model with softness of skin – shore OO, to enhance palpation skills in anatomy education.

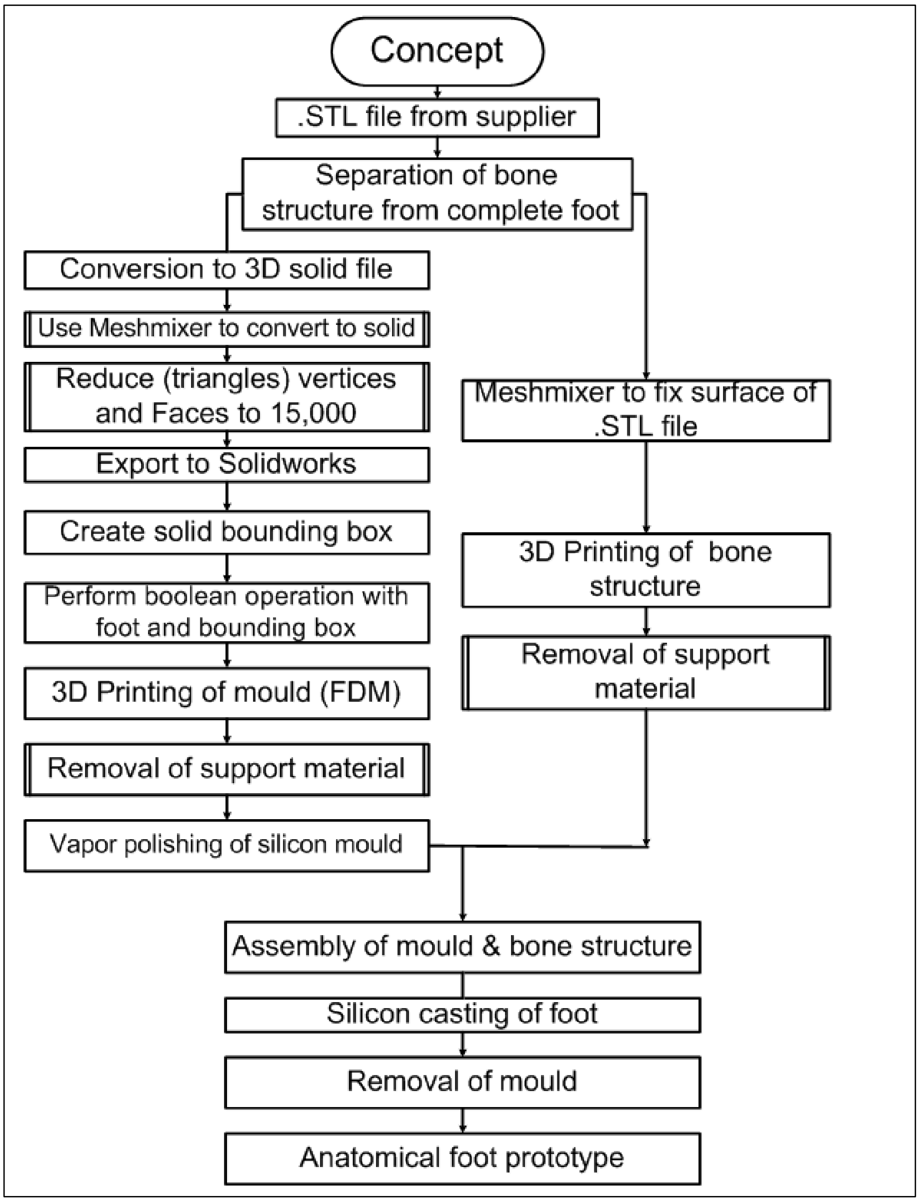

Figure 1 Fabrication process flow chart

2. Method

Fabrication process overview

Figure 1 shows the flowchart of the fabrication process. The input data file was received from Stratassys supplier in Sydney, Australia. This foot model data file is used for sales demonstration of Connex 260 3D printer (Stratassys Ltd, Eden Prairie, Minnesota) or higher 3D printers. The file was received in .stl (referred to as "Standard Triangle Language" and or "Standard Tessellation Language) mesh format.

Figure 2 3D Printed Transparent foot from Connex 260 machine

The received file was printed on a Connex 3D printer (Stratassys Ltd, Eden Prairie, Minnesota), cleaned by water jet and polished to achieve a transparent model with the bones visible – Figure 2. However the finished surface of the polished 3D printed foot was too hard to be use for teaching palpation skills in clinical anatomy. This hardness limitation of the 3D printed transparent anatomical model from the Connex 3D printer was the motivation for this paper. In essence, the motivation to develop a more interactive flexible model to better replicate 'real- life' practice and enhance 'hands-on' clinical skills.

2.1 Bone Structure Part

The first step in the fabrication process of palpable anatomical foot model was to group the mesh of existing .stl files and separate the bones structure from the rest of the foot tissues. The mesh of the bone structure through this process was not perfect as some holes and damage to the surfaces occurred. These non-closed surfaces caused errors on the FDM 3D printer files and therefore needed to be adjusted accordingly. A software feature in Meshmixer was used to assist the mesh repair and holes were also manually filled to obtain a smooth surface for the bone structure. Rods were inserted to hold the bone structure over the floor of the mould – Figure 3.

The 3D printed bone structure obtained with the Connex 3D printer is shown in Figure 4 (Stratassys Ltd, Eden Prairie, Minnesota).

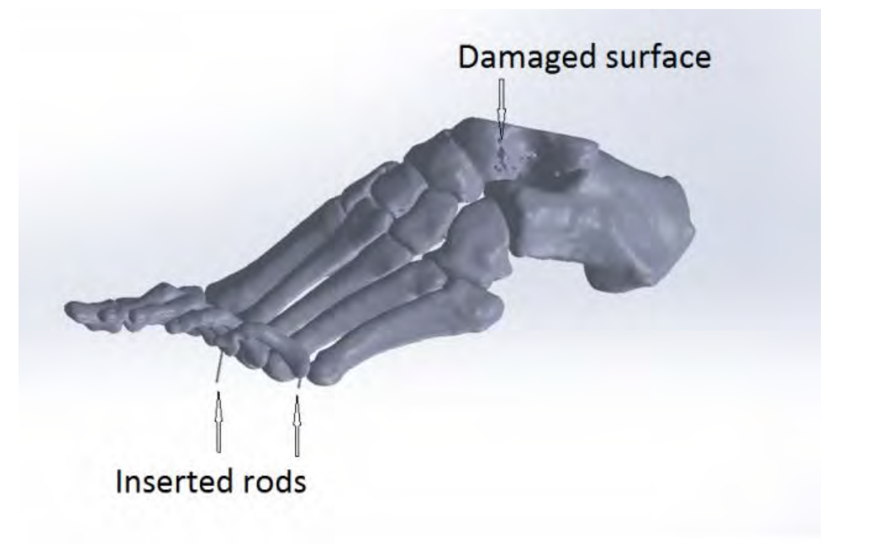

Figure 3 Surface rendering of the bone structure, showing damaged surface and inserted rods to create rooms for soft tissue structure in the mould

Figure 4 3D Printed bone structure

2.2 Soft Tissue Part

In this paper, no attempt was made to individually identify the different neurovascular, muscular or dermatological structures of the foot. Instead, all these features were captured as a whole so the resulting mesh file received from the separation of the bone structure was the overall soft tissue structure. The resulting .stl file was filled; surface holes fixed and smoothed using open source software Meshmixer (© 2016 Autodesk, Inc.). From this a negative foot mould was 3D printed in acrylonitrile butadiene styrene (ABS) filament, layered at 20 microns on a Makerbot (Stratassys Ltd, Eden Prairie, Minessota) finite definite method (FDM) 3D printer.

2.3 Creating solid body file

In order to create a negative mould, a solid file of the soft tissues part of the foot was needed. Firstly, Meshmixer (© 2016 Autodesk, Inc.) software was used to convert polygons from .stl to the solid model. Meshmixer is a free, open source software package for working with triangle meshes. The .stl files of the soft tissue structure was imported into Meshmixer. The imported polygons were combined to form one entity using a "Combine" function in Edit menu. After the files were combined to form a 3D surface, another function in the edit menu was used to convert the 3D surface file to a solid structure file. While there are three different modes of converting .stl files to solid in Meshmixer, the "Accurate mode" was found to be more suitable to reduce shape distortion in this project. The parameters used were: Mesh Density = 512; Offset Distance = 0; Min Thickness =0 and Cull Edges Threshold =100.

2.4 Reducing Surface Triangles

The steps described above were not possible in Solidworks (Dassault Systèmes SolidWorks Corporation, Waltham, MA, USA) because of the limit on the surface triangles that Solidworks can process. The limit was 100,000 but the surface triangles of the original .stl files were higher due to more details/resolution needed for 3D printing. An open source software Meshlab was used to estimate the number of surfaces. According to Meshlab software, there were 98,048 Vertices and 198,068 Faces in the received .stl file.

Meshmixer was used to reduce the surface triangles. The "Reduce" function in the Edit menu of Meshmixer was used to achieve this goal. "Triangle budget" mode of 15,000 surface triangles was selected for this step. This function preserved the shape or boundaries when reducing the surface triangles in Meshmixer and at the same time corrected surface errors in the 3D CAD model. The resulting file was then smoothed, and holes filled using other functions before saving as .stl solid body file.

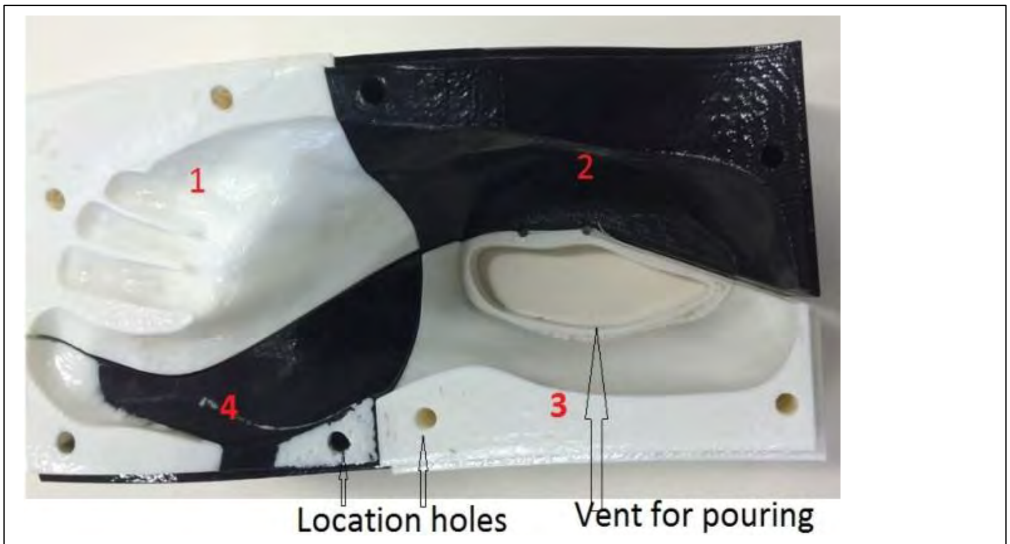

Figure 5 The upper mould for the soft tissue

2.5 Box Frame for Mould

The negative mould for the soft tissue structure was a combination of the Boolean operation of the box frame designed in Solidworks and the soft tissue structure solid files prepared according as described above in this paper. Further design improvement was performed to prepare the bounding box for silicon casting.

The soft tissue mould was split into six parts. The upper mould component had four parts – Figure 5 and the lower mould two parts – Figure 6. The parting line for the box frame was designed for easy removal of the casted model as particular care was needed for the toe shapes to avoid damage to the mould. The box frame was designed using Solidworks, and sloped to prevent leakage of any liquid material, and to ensure proper coupling of the six parts.

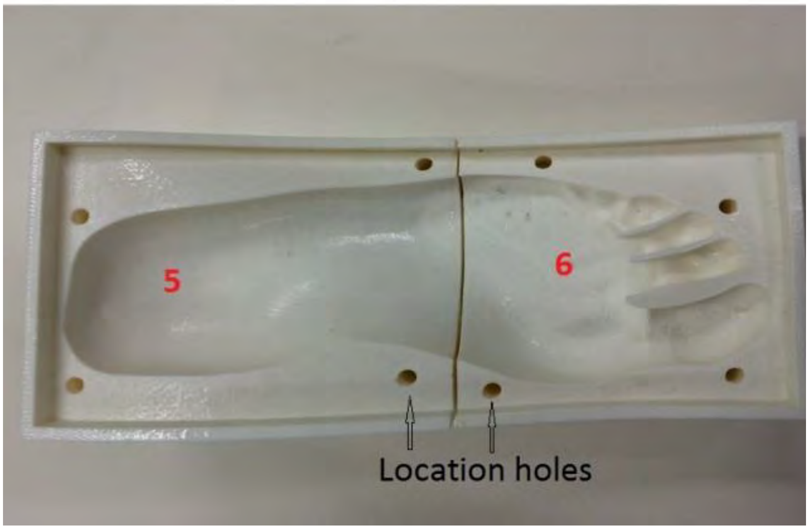

Figure 6 The lower mould for the soft tissue

Figure 7 The fabricated foot of shore 00

Location holes were added in the mould box design. The location holes served two purposes. Firstly, the proper location and fitting of the six parts of the mould when assembled before casting. Secondly, the nuts and bolts fitted through the location holes were used for clamping of the box frame together in preparation for pouring of the silicon compound mix and also to hold the mould in place after pouring. The vent provided access to pour the silicon casting mix and eliminate gas bubbles from the silicon compound mix.

2.6 Mould surface preparation for silicon casting

It was imperative to have a smooth surface finish for the mould as the even the slightest imperfections could be replicated in the final model. FDM (Fused Deposition Modeling) machine Makerbot Replicator 2X (Stratassys Ltd, Eden Prairie, Minessota) was used to 3D print the mould using acrylonitrile butadiene styrene (ABS) filament. The completed design of the mould was converted to a standard tessellation language (.stl) format for input into the FDM machine. An internal sub-program in the FDM machine sliced the CAD model and generated the material deposition part. A standard layer thickness of 0.05 mm and infill of 50% was set for the mould 3D printing on the FDM machine.

The resultant layer-by-layer deposition of 3D printing process of parts by the FDM machine created a high surface roughness due to stair-stepping effect of this process. However, the surface roughness was improved by a chemical method using acetone vapour smoothing which did not affect the dimensions of the 3D printed parts suggested by Espalin D, et al, (2009).

2.7 Assembly and Silicon Mix Casting

The box frame (mould) with the bone structure inside was clamped together using M6 nuts and bolts that fitted into the location holes. Platsil Gel-00 Prosthethic Grade Silicon was purchased locally for this project. This gel was a two component silicone rubber and accelerant which cures at room temperature. A 1:1 ratio by weight, of the accelerant and silicon rubber produced the desired shore 00. The compound was carefully mixed in order to avoid creating air bubbles and poured into the clamped box frame. A release agent was applied to the internal surfaces before pouring of the silicon compound mix. The release agent used was J-Wax Aerosol manufactured by Jacobson Chemicals Limited for use in moderate temperature to facilitate demoulding.

The box frame mould was placed on an angle so that the compound would flow deep to all corners of the box frame before hardening, thus pushing out air from under it. After the mould was half filled with the silicon compound mixture, this was allowed to set for few minutes so that the poured mixture would level out. The remainder of the silicon compound mixture was then poured into the mould until the bone structure was covered completely.

3. Results And Discussion

An anatomical foot model of shore OO was fabricated (Figure 7). The desired shore OO was achieved to enhance ‘hands-on’ palpation skills in anatomy education. Even though 3D printing technology is expanding and becoming increasingly available, there is still room to combine traditional manufacturing techniques to achieve desired goals, particularly when specific material densities are required.

Different scales are used to measure hardness of different materials. The durometer hardness test is the international standard for measuring the hardness of rubber, plastic and most non-metallic material. The ASTM D2240 – 15, standard was used in this paper. The durometer hardness discussed by Qi H. , et al (2003) which covers nine types of durometer 'shore' scales: A, B, C, D, DO, M, O, OO and CF, the suffix to the scale number represents the rubber hardness on the shore scale. According to the ASTM Standard, the scale OO is for extremely soft rubber, thermoplastic elastomers, sponge, extremely soft plastics and thermoplastics, foams, low-density textile windings, human and animal tissue.

The 3D printed materials on the Connex 260, Tango Plus™ were reported to have hardness 27 shore A by Shimoga & Goldenberg (1996), which was not consistent with the desired hardness level required to palpate different anatomical structure to enhance anatomical education for students. The authors' proposal of using silicon gel compound of shore OO was found to be an alternative solution. From durometer table in Qi H Jet al(2003), it is evident that extra softness is best achieved with shore OO, to be best knowledge of the authors; there is no commercial 3D printers that can print shore OO.

For some applications of 3D printed parts, post-processing operations are needed to improve the surface roughness which have also been discussed by Gurpal Singhand Bual Parlan Kumar (2014) and Chil-Chyuan Kuo and Shong Jie Su (2013). The surface roughness can be improved by a number of methods specifically by changing process parameters suggested by Maruthi M, et al, (2014), and Nancharaiah T, et al, (2010). Chemical method of improving surface roughness discussed by Galantucci L M et al, (2010), Percoco G et al, (2012), and Espalin D, et al (2009), as well as mechanical method was also used to increase surface roughness, discussed by Kulkarni P, & Dutta D, (2000), Williams R E Melton V L (1998), and Pandey P, et al, (2003). Some authors also suggested mathematical method for improving surface roughness for example Ahn D, et al (2012, 2013).

The authors of this paper opted for the chemical method because of green manufacturing requiring less waste and reduced complexity. The chemical method used for this fabrication was acetone vapour smoothing as suggested Espalin D, (2009) which did not appear to change the 3D printed part dimensions.

The cost of fabricating 3D print models for health and medical curriculums can be prohibitive Korf H, et al (2008). However, the cost of machines and consumables has been reducing in the last few years. The material costs to print the bone structure for the foot in this project was AU$442.36. The Platsil Gel-00 Prosthethic Grade Silicon cost was AU$115.50. The cost of printing the mould on FDM machine was AU$275.00. Overall the approximate total cost of one of foot was AU$832.86, excluding labour cost. However, subsequent fabrication is inexpensive because the mould can be re-used.

3D printing is becoming more available for a wide range of applications. Most of the software used in this research are open source which are easily accessible for use. The basic versions of this software can be downloaded and installed for free. With the recent growth of internet based 3D printing services, files created can be 3D printed at low cost without the need to purchase expensive 3D printers. Fabricating educational specific 3D print models may be an increasing viable and integrative way to supplement anatomical and clinical education.

4. Conclusion

In this paper, how to fabricate an anatomical foot model with a 3D printing and silicon casting process to provide a model with both skeletal density and soft tissue pliability was outlined. Whilst achievable, problem solving processes are needed. Different software was needed to repair mesh polygons and create solid geometries by Boolean operations.

A common issue with CT scan images used in 3D printing is to create a 3D surface. One method to fix surfaces of mesh triangles or polygon of CAD models using open source software is shown in this paper. The fabrication of anatomical soft models is now feasible. Future samples prepared will include steps to remove air bubbles in the silicon compound by subjecting it to negative pressure in a vacuum chamber. This fabrication process can also be applied to humanoid robot hands or body parts.

The advantages of the fabricated soft tissues anatomical foot model are durability, ease of reproduction, cost effectiveness and less Work Health and Safety issues associated with plastinated and cadavers specimens used in medical education. Functional 3D models are likely to be a viable resource to stimulate palpation skills for increased engagement and the ability to practice and revisit the information for anatomy students. Studies are needed to evaluate the ulitity of the innovative interactive 3 D print models to enhance student clinical ability and confidence when assessing anatomical structures.

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Evolution of Master of Engineering Coursework Degrees at Western Sydney University: Past, Present and Future

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Abstract:

Engineering curricula are always subjected to changes as academics and university administrators take up prevailing ideas and respond to technological changes and operational challenges. In Australia, there is a need to meet interests of potential international and domestic students of varying backgrounds to pursue high-quality postgraduate studies. This paper describes the genesis of the coursework based Master of Engineering program at Western Sydney University (WSU) from its inception to the near future. It is shown how the structure of the program has dynamically changed to meet student needs and accreditation requirements.

Keywords: Engineering education, Curriculum development, Student centred learning, Accreditation

1. Introduction

Engineering curricula are always subjected to changes as academics and university administrators take up prevailing ideas and respond to technological and operational changes. Introduction of blended learning is a good example of contemporary approach in Australian universities facing funding shortages and the concomitant need to cater to large student cohorts while maintaining student to staff ratios at current levels.Formalization of such changes takes into account the mission, aims and objectives and strategic plans of the university. In the WSU case these are summarized in the strategic plan (WSU, 2015). Moreover engineering courses are subject to the requirements of their profession. Thus changes are often influenced by external factors. Thus a substantial change in the culture of the organisational unit responsible for the delivery of the curriculum is called for (Heywood, 2005).

According to Heywood (2005), the role of the curriculum designer is to determine (a) the aims and objectives (course learning outcomes (CLO) or learning targets) of the course to be given, (b) the best methods of achieving those aims and objectives, (c) the unit sequence, and assessing if as a result of (b) and (c) they have been achieved. Traditionally the last process has been called evaluation. Evaluation embraces the assessment of student learning and determining if learning targets have been met and at what level. It would detect mismatches between the formal learning environment and the experiences of students in that environment achieving desired outcomes. It would also include the evaluation of teaching performance, the continuing appraisal of goals in response to sociotechnical change, and the attention to the core values of the course (program) (Heywood, 2005).According to the 2015-2020 Strategic Plan (WSU, 2015), the University is embracing the above challenges with a renewed focus on a number of areas that will be key to its success. Traditional approaches will cede to more creative solutions to advance world-class teaching and curricula. WSU will extend its international reach and global standing through its students and graduates, its research, and its expanding partnerships.

The aim of the paper is to conduct a retrospective audit of the PG masters' program structures to determine how they meet both student and university expectations.

2. Program Objectives

The Master of Engineering coursework program at Western Sydney University has evolved since its inception in early 2000. This evolution can be described in 3 distinct stages: Stage 1, in early 2000s, creation of a one-year generic Master of Engineering program where students are at liberty to choose specialised units offered in civil, environmental, mechatronic, electrical, computer and telecommunication engineering. Stage 2, in mid to late 2000s, units were rationalised and consolidated together with the creation of distinctive key areas in civil, environmental, mechatronic, electrical, computer and telecommunications engineering. The program remained as a one-year program.

In Stage 3, in mid 2010s, the one-year program was restructured to a two-year program (not including a one-year preparatory study) with addition of new core and specialised units. Moreover, as mentioned before, provisional Engineers Australia (EA) accreditation was sought and approved. The specialisation areas were amended to civil, environmental, mechanical, mechatronic, electrical and telecommunications engineering. Further changes in future are being planned to create further flexible pathways for potential domestic and international students interested in pursuing coursework Masters at Western Sydney and in preparation for seeking full EA accreditation for the program.

The restructuring undertaken in 2013-14 was aimed to:
(i) comply with Australian Qualifications Framework (AQF) requirements
(ii) achieve Engineers Australia (EA) professional accreditation of Stage 1 competencies, which means that some foundation/developing engineering and capstone units are required to be taught.
(iii) renew the master of engineering program to provide for a rounded as well as a more specialised learning experience for both domestic and international engineering students, two groups who are not necessarily attracted to the program for the same reasons and aspirations.
(iv) establish a presence of postgraduate engineering at Parramatta campus of WSU.

"The AQF is the national policy for regulated qualifications in Australian education and training. It incorporates the qualifications from each education and training sector into a single comprehensive national qualifications framework. The AQF was first introduced in 1995 to underpin the national system of qualifications in Australia encompassing higher education, vocational education and training and schools." (AQF Second edition, 2014) The WSU engineering master's program was designed to be compliant with AQF Level 9 to meet accreditation requirements of the agency and to concurrently meet EA accreditation requirements as detailed in EA (2015).

Accreditation was a critical aim of the restructure since it provides an internationally benchmarked standard for judgment of postgraduate engineering education programs, because the accreditation process assures the competence of graduates and provides a guarantee of standing that is independent of the education provider. There were only a handful of programs accredited at postgraduate level in the Australian tertiary education sector and there was a need to develop new course offerings in response to international market demand.

3. Course Overview of Postgraduate Engineering Courses (Stage 3 of Restructuring)

Design Concept:

Table 1: Key learning components in postgraduate coursework programs

Course	**Key Learning Components (Credit Points, CP)**					
	Specialisation	Sustain-ability	Communi-cations and Professional Practice	Project	Research	Electives
Grad Cert in Eng	≥ 30 CP	≥10 CP	10 CP	0	10 CP	10 CP
Grad Dip in Eng (exit program only)	≥ 40 CP	≥10 CP	10 CP	≥ 0	10 CP	20 CP
Master of Eng	≥ 50 CP	≥10 CP	10 CP	20 CP	30 CP	30 CP

Notes:

- Specialisation: This component is designed for teaching of specialist skills and knowledge in the chosen specialisation
- Sustainability: Understanding the principles of sustainable design and development to meet human needs in the present while preserving the environment for the needs of future generations.
- Communications and Professional Practice: Understanding the ethical and moral responsibilities of the professional engineer, and the need for effective oral and written

communication skills.

- Project: Application of established engineering methods in a holistic way to solve complex engineering problems within the context of a capstone project.
- Research: A systematic inquiry to identify and develop alternative concepts, solutions and methodologies.

The suite of postgraduate coursework programs in engineering following the recent Stage 3 restructuring consists of: 160 CP Master of Engineering, 120 CP Graduate Diploma in Engineering (exit program only) and 80 CP Graduate Certificate in Engineering. The programs provide opportunities to develop specialised technical and research skills for application in professional engineering practice. It is structured with facilitated learning and directed research aimed at technical- and research-based skill development that encourages critical review, analysis, consolidation and synthesis of knowledge, and critical thinking. Students analyse realistic situations and adapt proposed outcomes based on their understanding of the theory and the related body of knowledge. In addition the course provides opportunities to apply and adapt knowledge and skills in diverse contexts and environments thus fostering increased awareness of sustainability, collaboration, communication and uptake of responsibility and accountability in line with expected professional practice.

Table 1 highlights the breakdown of the key learning components covered in each coursework program. These components are designed to achieve specified learning outcomes for students to develop the required competencies in their professions.

Master of Engineering

The restructured Master of Engineering (specialisation) course is a *160 CP two-year equivalent full time* program structured as follows:

- 8 x 10 CP Master of Engineering core units (including Master Project 1, Master Project 2, Advanced Design Project 1, Advanced Design Project 2 from chosen area of specialisation)
- 5 x 10 CP specialised units (alternates) from chosen area of specialisation.
- 3 x 10 CP electives

The course offers specialisations in Civil, Environmental, Mechanical, Mechatronic, Electrical and Telecommunication engineering. It is designed for both domestic and international engineering graduates with an undergraduate degree within the same specialisation. It is meant to be both AQF- and Engineers Australia (EA)-compliant, the latter requirement is for accreditation of EA Stage 1 competencies. However, the more stringent requirements are mainly the result of the need for Engineers Australia compliance.

Three-year BEngSc graduates and BEng graduates from another discipline will be required to complete a preparatory study before articulation into the two-year MEng program. The Preparatory Study is an *80 CP one-year full time or two-year part time* non-award program. Alternatively, students in this category may undertake and complete an EA-accredited BEng course to articulate into the MEng. Advanced standing will be granted for relevant prior studies in accordance with WSU policies. Students will have the flexibility of choosing sub-specialities.

Graduate Certificate in Engineering

The Graduate Certificate in Engineering is an *80 CP one-year equivalent full time* non-EA-accredited engineering program completely embedded in the Master of Engineering. It consists of 4 x 10 CP core units 3 x 10 CP specialised alternates from chosen area of specialisation and 1 x 10 CP electives.

Graduate Diploma in Engineering

The Graduate Diploma in Engineering is a non-EA-accredited *exit-only program*, awarded for successful completion of *120 CP* units consisting of 6 x 10 CP core units, 4 x 10 CP specialised alternates from chosen area of specialisation and 2 x 10 CP elective.

Master of Engineering Specialisations
The specializations offered at the inception are Civil, Environmental, Mechatronic, Mechanical, Electrical and Telecommunications

Course Learning Outcomes
The Course Learning Outcomes (CLOs) and EA Stage 1 Competencies, WSU Graduate Attributes and AQF specifications are all met following a judicious selection of each in core units and within the various specialisations.

Preparatory Study
Preparatory Study is a non-award program for 3-year Bachelor of Science graduates and 4-year Bachelor of Engineering graduates in another specialisation seeking articulation pathway into Master of Engineering program. Advanced standing may be granted for units in Preparatory Study on a case-by-case basis, but it must be justified by supporting and verifiable evidence. The non-award Preparatory Study is an AQF level 8 program specifically designed to complement the Master of Engineering (AQF level 9) to ensure students from a non-engineering science background or a *different engineering discipline* to the one chosen for the Master of Engineering study will be adequately equipped to undertake the following 2-year Master level study. The one-year full time Preparatory Study and the two-year full time Master of Engineering together constitute a study duration of 3-years full time.

4. Pathways, Academic Credit, Entry and Exit Points

*Entry Pathways*Students entering the WSU Master of Engineering programs must have at least a recognised Bachelor of Engineering or Bachelor of Science degree. The pathways for entry into the Master of Engineering are stringent and varied depending on what students have fulfilled in their previous studies. In line with the requirements for accreditation, students will be assigned to one of the following entry bands according to their qualifications:

Band A: a recognised 4-year Bachelor of Engineering degree accredited by Engineers Australia or equivalent in the *same engineering discipline* as the chosen specialisation for the Master of

Engineering study

Band B: a recognised 4-year non-accredited Bachelor of Engineering degree or equivalent in the *same engineering discipline* as the chosen specialisation for the Master of Engineering study

Band C: a recognised 3-year Bachelor of Engineering Science accredited by Engineers Australia or equivalent (namely the first part of the "3+2" Bologna model) in the *same engineering discipline* as the chosen specialisation for the Master of Engineering study

Band D: a recognised Bachelor of Science or Bachelor of Engineering degree from a *different discipline* as the chosen specialisation for the Master of Engineering study

Band E: a recognised non-accredited Bachelor of Engineering Science or equivalent in the same discipline as the chosen specialisation for the Master of Engineering study

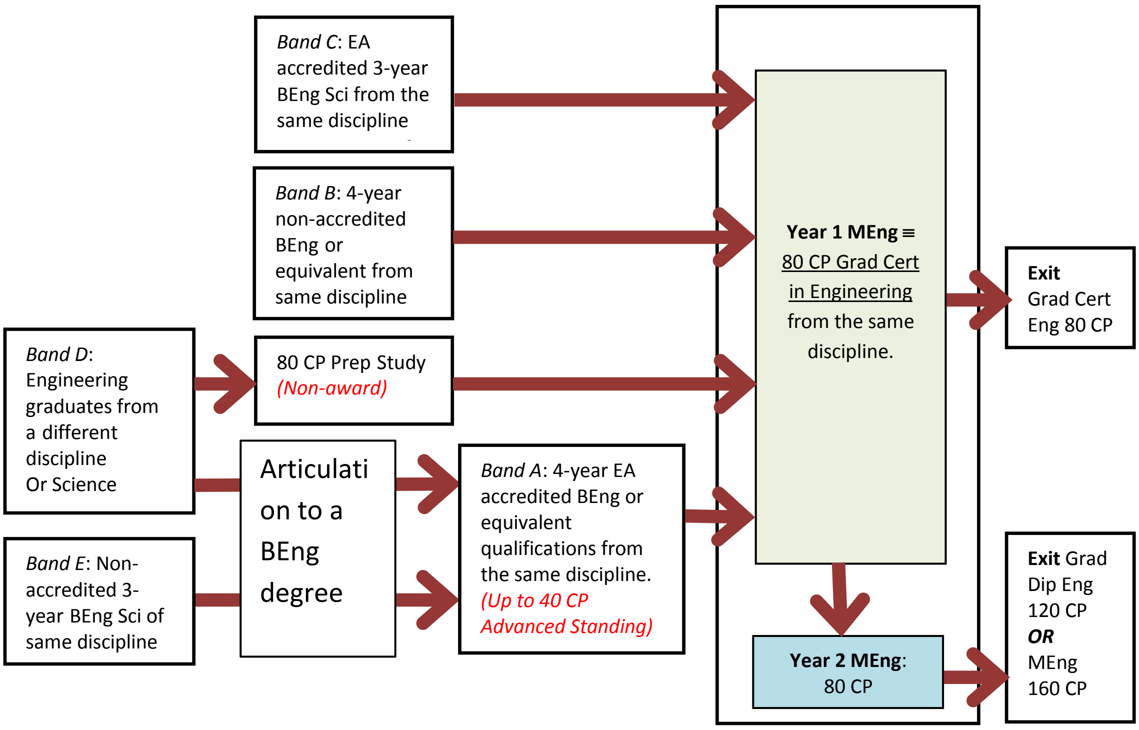

Figure 1: Pathways for admission to the Master of Engineering programs

The pathways for entry into the Master of Engineering program are shown schematically in Figure 1. It is noteworthy that:

a) Only students in *Band A, B* and *C* are allowed direct entry into the 2-year Master of Engineering programs (i.e. they would be granted advanced standing credits for the 1-year Preparatory Study). Students in *Band A* may be further granted advanced standing credits for some of the units in the Master of Engineering programs.

b) The articulation pathway for students in *Band D* is either through the one-year non-award Preparatory Study or the 4-year accredited Bachelor of Engineering degree, depending on the curriculum of their undergraduate studies.

c) The articulation pathway for students in Band *E* is through the 4-year accredited Bachelor of Engineering degree.

The pathway in Figure 1 satisfies EA's requirement of nominally 3-years full time study for a conversion style masters' program aimed at the Professional Engineer outcome, on the basis of a candidate entering with a non-engineering bachelor's degree, but satisfying minimum entry requirements for mathematics and general sciences. This pool of students, however, is expected to be relatively small and is not a main target of the current course.

Exit Points

The Master of Engineering course is nominally three-years in length with a two-year study program at the postgraduate level (PG) with either recognition of prior learning for students of particular background or the necessity of undertaking the one-year 80 CP non-award Preparatory Study which is the pathway for articulation into the Master of Engineering (refer to entry pathway discussion). Figure 2 below shows the entry and exit points of the Master of Engineering course, including early exit awards at Graduate Certificate and Graduate Diploma in Engineering. A *banding system* (as discussed above) is used to determine whether an applicant qualifies for direct or indirect entry (via the 80 CP Preparatory Study program) to the Master of Engineering programs.

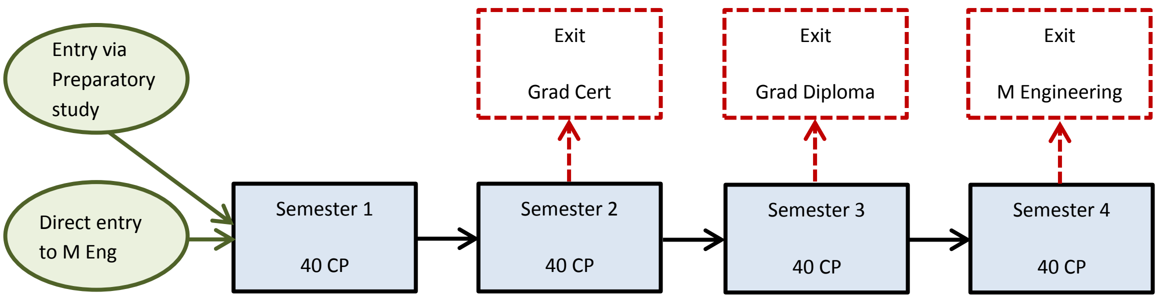

Figure 2: Entry and Exit points of Master of Engineering programs

5. Marketing of the Course and Future Development

Marketing

A 2-year full time 160 CP Masters' program accredited by Engineers Australia is clearly seen as an attraction for international students, and has been marketed as such. The attraction to domestic students depend on the de-linking the PG units from the associated undergraduate unit and the potential of high calibre industry professionals to contribute to the teaching. The former is a "chicken-and-egg" problem which depends on class size, and the latter will need to rely on the industry connections of the academics.

Future Developments

WSU is preparing to move the delivery of the MEng programs from Penrith Campus to Parramatta Campus. The centrality of Parramatta Campus is an added attraction not only for the international students but facilitates travel for the domestic students as well. One of the key areas for improvement is to seek an increase of the enrolment of domestic students. This is to be done by providing flexible learning, relevant professional content along with an attractive location. With the move, it is timely to review existing pedagogy and introduce new modes of delivery and blended learning in response to the needs of students. This includes a multitude of formats: online, on-campus (traditional and workshops) and situated. All of these formats are currently being trialled and the experience will serve to facilitate conversion from the traditional to blended learning. The central location of Parramatta could also make the evening offering an attractive feature for our PG courses. Another possible development is on increasing the choice of specialisation to students by looking into expanding the specialisation areas.

6. Conclusion

The Master of Engineering coursework program at Western Sydney University has evolved in various stages since its inception in early 2000 to mid 2010. This evolution can be described in 3 distinct stages: Stage 1, creation of a one-year generic Master of Engineering program where students are free to choose specialised units offered in civil, environmental, mechatronic, electrical, computer and telecommunication engineering. Stage 2, units were rationalised and consolidated together with the creation of distinctive key program areas in civil, environmental, mechatronic, electrical, computer and telecommunication engineering. The program remained as a one-year program. Stage 3, the one-year program was revamped to a two-year program with addition of new core and specialised units. Moreover, provisional Engineers Australia accreditation was sought and approved. It is expected that the new program will achieve better outcomes to all the stakeholders of this course.

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STEaMing Ahead with Engagement

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Abstract: Science, Technology, Engineering and Mathematics (STEM) skills are in decline in Australia and with Digital Disruption upon us, the future looks vastly different for school students in this generation compared to previous ones. Research suggests that students need digital literacy regardless of their intended career path, as developments in technology significantly alter our future working environments. With 75% of the fastest growing occupations needing STEM related skills and experience, and many careers of the future yet to be defined, an increase in engagement and participation in STEM related disciplines is crucial.

The School of Computing, Engineering and Mathematics at Western Sydney University therefore makes engagement a high priority and actively works with other units in the University to offer quality service in engagement support. Embedding a collaborative approach, we eagerly seek to work with other areas and engage with external parties such as teachers and school students, industry and general community members. With outreach initiatives such as MakerSpace access, school holiday workshops and teacher professional development, the aim is to create value rich experiences that engage a variety of audiences and encourage STEM participation.

Keywords: STEM, engagement, education, students

Restructuring higher education in Norway – consequences for engineering education

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Abstract: In recent years there have been several processes were university colleges have merged with other university colleges or with universities in Norway. The first part of this paper presents the processes and the new structure of Norwegian higher education. There are multi-campus universities with faculties and departments with employees and students on different campuses. This has led to several ways of organizing the institutions.
The second part of the paper gives an overview of engineering and technical education in the new structure. The educational programmes have to be coordinated or equal, and there must be stronger cooperation between employees at the various locations who teaches at the same educational programmes.
The third part of the paper gives a more detailed description of three merging processes UiT - the Arctic University of Norway has completed: first with Tromsø University College (2009); then with Finnmark University College (2013); and then with Narvik and Harstad University Colleges (2016). As a result number of students has increased from ca. 5000 to ca. 15000 and the number of employees has increased from ca. 2000 to ca. 3500. In 2009 engineering education was located at Tromsø University College. Today the recruitment of students has improved, new engineering programmes, and master and PhD programs have been developed. In the processthe engineering education department was moved to the main campus in a new Technology building. After the merger with Narvik there are new programmes, and equal programs from both institutions that have to be coordinated, and collaboration of staff members are increasing. Education methods like streaming of lectures are used to get more equal education.

Keywords: Norwegian university structure, engineering education

1. Introduction

In recent last years, there have been several processes were university colleges have merged with other university colleges or with universities in Norway. A new merger process was initiated by the Minister for Education and Research Torbjørn Røe Isaksen (Isaksen 2014). The overall goal will be higher quality in higher education. In the initiating speech, seven measures for higher education and research over the next four years were presented.
In the new process, the funding system for higher education and research will be examined to see how changes can help strengthen quality. The funding from government consists of multiple components: A basic allocation and performance-based component including completed credits (ECTS); exchanges of students; scientific publications; number of PhD; EU projects and funding from the Research Council of Norway. I addition, projects can be funded by industry and other organisations. In Norway, higher education is free for the students, and students get grants and loans for living (including foreign students).

It is likely that one of the conclusions will be that the number of institutions will be reduced, but not the number of campuses. The quality requirements have consequences for the structure.
Other gaols of the new processare:

- Norway should develop more world leading research (invest in relevant research environments and institutions that can contribute to breakthrough research in the world).
- Ensure that Norway succeed in the new EU research programme Horizon 2020.
- Working conditions should be secured, including recruitment, employment and career structure.
- Better teacher education. Good teachers are the foundation of the knowledge society. How well we succeed in the higher education sector as well as the rest of society depends on good teachers. National programmes for teacher education will be increased from four to five years (Master programmes).

The structure was examined and recommendations for new structure were presented for the Norwegian parliament (The Storting) in a white paper (White paper to the Storting) in the spring 2015. The minister of education and research held several meetings with universities and university colleges, and they sent their final submissions with a "description of the preferred strategic position in 2020 and an evaluation of the main steps that must be fulfilled in order to reach that position. The institutions were requested to evaluate how they can become stronger through mergers with other institutions, or how they can lift quality at other institutions through mergers with them. The Ministry has encouraged extensive contact between institutions both within and outside their own regions."
The white paper (Meld. St. 18 (2014 – 2015)) was presented for the Government in March 2015, and passed the Storting in June 2015. Then each of the merged institutions were confirmed by the government in royal decrees from June to October 2015, with effect from January 1. 2016.
In each of the effected institution, there have been processes to merge and establish cooperation between departments on equal fields of research and education. Almost every institution has programmes in nursing education, teacher training and engineering education.
The Basic Agreement for the Civil Service (Hovedavtalen) gives organizations the right to participation in the processes of restructuring and merging of institutions, and there are special agreements for those processes (Personalpolitikk ved omstillingsprosesser).
In the white paper (Meld. St. 18 (2014 – 2015) the organization and governance are described. Every institution has a board with normally 11 members, but the new boards (from Jan 1. 2016) are extended with members from the campuses or departments (former University Colleges). Some institutions have an elected rector, others have an appointed rector. The internal organization has three or four levels. At level two, there are faculties and departments and units, and at level three there are departments under each faculty. There is also a more or less formal level four, like research groups or teacher teams for each programme.

2. New structure of Norwegian higher education

The map (figure 1) shows the new structuring of higher education at Jan. 1. 2016 (Kunnskapsdepartementet 2016). Although the merger is valid from 01.01.2016, there are still many tasks that must be performed. The internal organization is not implemented in all locations, and personnel are to be placed in the new organization.
Category 1: Merged from Jan. 1. 2016:

- UiT – the Arctic University of Norway merging with Narvik UC (HiN) and Harstad UC (HiH).
- Nord University. Merging of University of Nordland, Nord-Trøndelag UC (HiNT) and Nesna UC (HiNe).
- Norwegian University of Science and Technology (NTNU) merging with Gjøvik UC (HiG), Sør-Trøndelag UC (HiST) and Aalesund UC (HiAls).

- University College of Southeast Norway. Merging Buskerud and Vestfold UC (HBV) and Telemark UC (HiT).
- VID Specialized University. Merging of private institutions: Deaconess College (DH), Misjonshøgskolen (MH), Haraldsplass Deaconess College (HDH) and Betanien UC (HB).

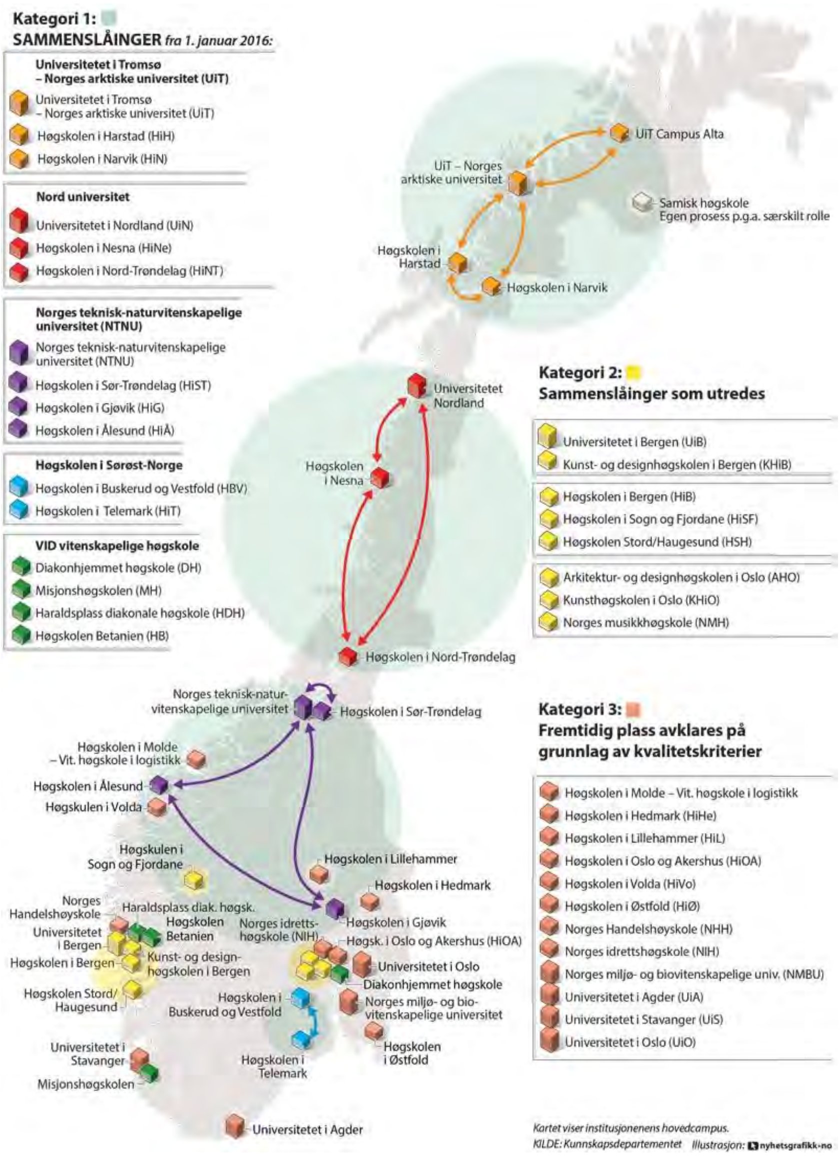

Figure 1 Changes in the HE sector from Jan 1 2016 (Kunnskapsdepartementet 2016).

Category 2: Merging is considered and discussed:

- University of Bergen (UB) and Bergen Academy of Art and Design (KHiB).
- Bergen UC (HiB), Sogn og Fjordane UC (HiSF) and Stord/Haugesund UC (HSH).
- The Oslo School of Architecture and Design (AHO), Oslo National Academy of the Arts (KHiO) and Norwegian Academy of Music (NMH).

Category 3: Merging processes will be decided based on quality criteria:

- Molde UC - Specialized University in Logistics, Hedmark UC (HiHe), Lillehammer UC (HiL), Oslo and Akershus UC (HiOA), Volda UC (HiVO), Østforld UC (HiØ), Norwegian

School of Economics (NHH), Norwegian School of Sport Science (NiH), Norwegian University of Life Science (NMBU), University of Agder (UiA), University of Stavanger (UiS) and University of Oslo (UiO).

The new structure has great geographical challenges with long distances between the campuses, and varying communication. As an example, between Tromsø and Alta (campus of UiT in Finnmark) there are flight connections several times a day (flight time is 40 minutes), and both Tromsø and Alta have airports close to town (10 min from campuses). On the other hand, the best connection between Tromsø and Narvik is by car which takes about four hours. Electronic communication and meetings are therefor used extensively.

3. Engineering and technical educations in the new structure

In the "old" structure, the universities had both 5 years Master of Science Programmes (NTNU 2016) and 3 years Bachelor programmes and 2 years Master of Science programmes (3 + 2 model), and the university colleges had mostly three years BA programmes. In the new structure, more Master programmes will be established on the new campuses (former UC).

Engineering education is available at most of the campuses:

- UiT at campus Alta, Tromsø and Narvik
- Nord University at campus Levanger
- NTNU at campus Tromdheim, Aalesund and Gjøvik. NTNU has been the leading technical university in Norway, traditionally offering five years master programs. With the merging, several three years BA programs are included, and the students can continue on master programs. The new campuses have included new fields of technology including the strong maritime sector in Aalesund with cooperation with the industry, and the information security in Gjøvik.
- Bergen UC (HiB), Sogn og Fjordane UC (HiSF) and Stord/Haugesund UC (HSH).
- University of Stavanger
- University of Agder at campus Grimstad
- University College of Southeast Norway at campus Porsgrunn, Kongsberg, Drammen(?), Horten (Vestfold)
- Oslo and Akershus UC
- Østfold UC
- Norwegian University of Life Sciences (NMBU)

The education programmes have to be coordinated or equal in each institution, and there must be stronger cooperation between employees at the various locations who teaches at the same educational programmes or have joint research areas.

4. Three merging processes at UiT - the Arctic University of Norway

UiT - the Arctic University of Norway has completed three merging processes, first with Tromsø University College (2009), then with Finnmark University College (2013), and then with Narvik and Harstad University Colleges (2016). The most important goal for UiT from the beginning in 1971 has been educating highly trained personnel in northern Norway, especially doctors.

The figures below show the growth of UiT from 2008 to 2016, from about 5000 to 15500 students (figure 1), from 2100 to 3400 employees (figure 2), and the ratio students to employees from 2.6 to 4.6 (figure 3).

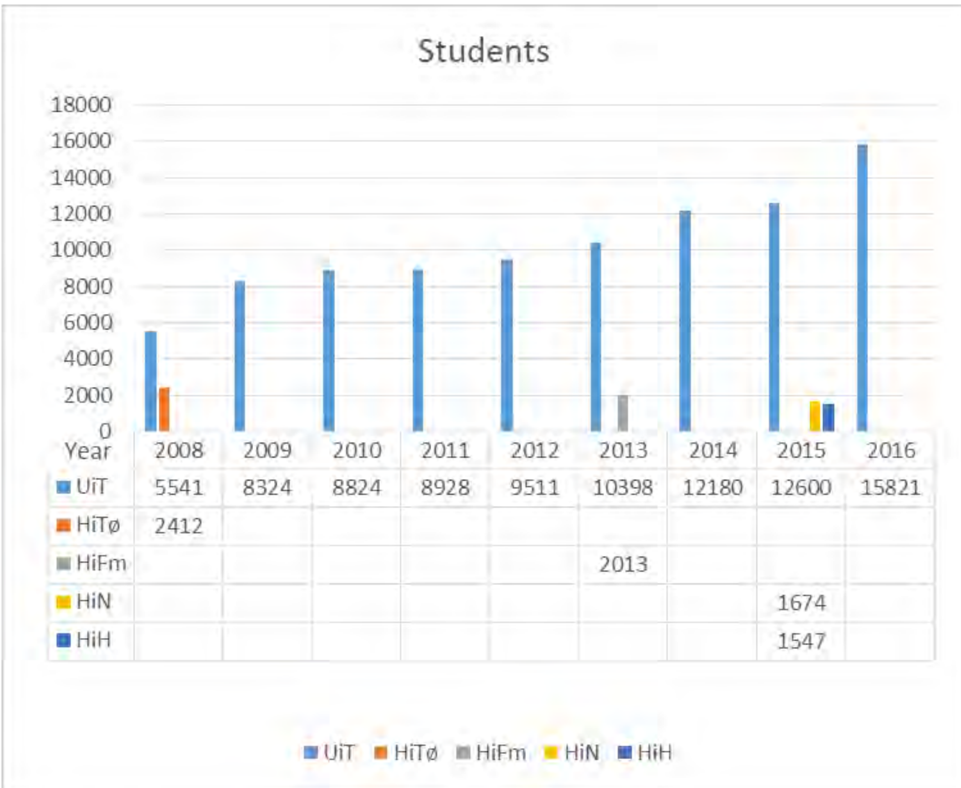

Figure 2 Students at UiT. Data from 2015, 2016 is sum of the merged institutions at Jan. 1 2016 (DBH 2015).

Figure 3 Employees at UiT. Data from 2015, 2016 is sum of the merged institutions at Jan. 1 2016 (DBH 2015).

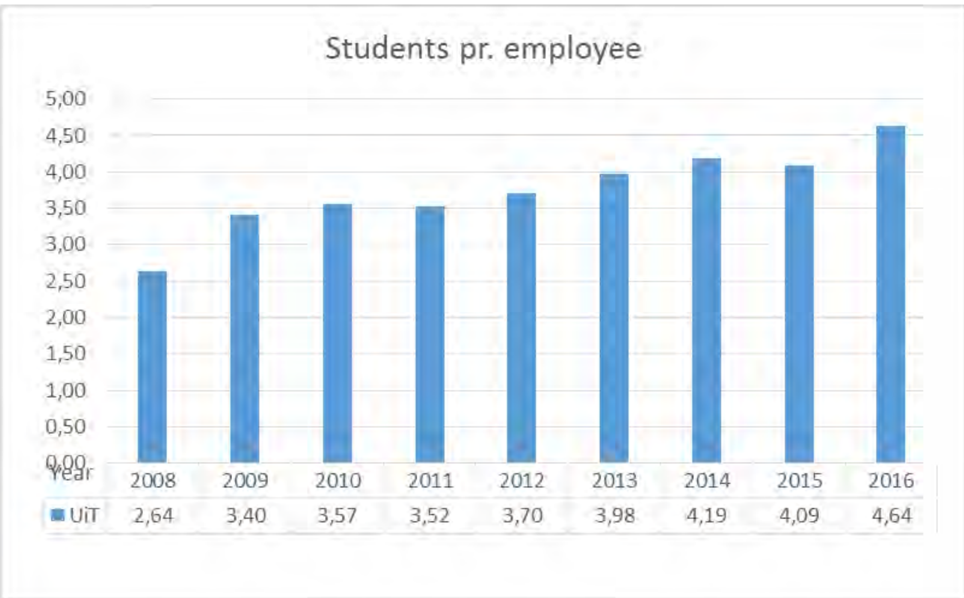

Figure 4 Students pr. employees at UiT. Data from 2015, 2016 is sum of the merged institutions at Jan. 1 2016 (DBH 2015).

In every merging process extensive work is done with working groups that study the departments and units that should be merged, and how. In the first merging process (UiT and Tromsø UC) the overall organization of the new university was analysed and changed. Both institutions were located in Tromsø, so there were no geographical problems. Tromsø UC had four departments; the Department of Engineering and Economics; the Department of Health Education (nursing); the Department of Education and the Department of Art (and Music). A goal was to move all the university to the same campus. Some of the result (for the UC departments) of this merging was:

- The Department of Engineering and Economics was split. The economists were included in the School of Business and Economics, this gave the students admission to master programmes.
- The engineering department was included in the Faculty of Science and Technology as the Department of Engineering and Safety. After the merger, the department has grown in number of employees and students. The department had BA programs in Automation Engineering, Nautical Engineering, Processing and Gas Technology, Security and Environment Engineering, and Societal Safety and Environment. After the merge, master programmes in Societal Safety and Technology and Safety in the High North and graduate of airline pilots (the only university BA program in Norway) have been established. Research groups are established, and research activities have increased.
- Teacher education from Tromsø UC was joined with the Department of Education and upgraded to five years master programmes, the first in Norway.
- Nursing education was centralised in the faculty of health.

The next merging with Finnmark UC in 2013 was a shorter process where fewer faculties were involved. The university name was changed from University of Tromsø to UiT – the arctic university of Norway.

- Nursing education was centralised in the nursing education in Tromsø at faculty of health, with education on both campuses.
- Teacher education was centralised in the Department of Education and upgraded to five years master programs with education on both campuses.
- Business education was included in the School of Business and Economics, and master programs were established.

- A new program in Arctic Civil Engineering at campus Alta was established by Department of Engineering and Safety.
- A new faculty was established in Finnmark (Alta) Faculty of Sports, Tourism, and Social work with three departments: Department of Child Welfare and Social Work, School of sport sciences and Department of Tourism & Northern Studies. The government initiated this faculty establishment.
- They have continued education at all campuses.

In the last merger with Narvik UC and Harstad UC the process started in 2015 with working groups for every merging department. The formal date of merging was Jan 1. 2016 (a practical date for terminating the UCs and including them in the university budget and administration), but the process is still going on. Our experiences from the former merger processes were useful in this process. The following are some of the results:

- A new faculty was established (initiated by the government) with faculty management in Narvik; the Faculty of Engineering Science and Technology, based on the technology department in Narvik UC. The departments are: the Department of Industrial Engineering; the Department of Building Energy and Material Technology; the Department of Computer Science and Computational Engineering; the Department of Electrical Engineering; and the Department of Engineering Science and Safety IVT. The last one is located in Tromsø, and was split out from Department of Engineering and Safety with staff, education and research groups active in Automation, Process and Gas technology, and the new program for Bachelor of Engineering in Drone Technology. This is a preliminary organisation.
- Business education in Narvik and Harstad are included in the School of Business and Economics in Tromsø, and master programme was established.
- Nursing education (Narvik) was included in the nursing education in Tromsø at the faculty of health.
- The administration is organized both according to the three levels and a campus administration (in Harstad) covering several services for all students and employees.
- The board of UiT is extended to 17 members with new members from former HiN and HiH.
- There are long distances between the campuses.
- Electronic communication and meetings are therefore used extensively.
- Narvik UC has also several internet based programs where lectures are streamed and stored in the learning management system. This should be used in other programs at UiT.

After all the merging processes, the organisation (figure 5) has become very complex and not optimal. There are faculties and departments of different sizes, and departments working on almost same fields that are not merged (yet). There are two faculties if technology (Faculty of Science and Technology in Tromsø and Faculty of Engineering Science and Technology in Narvik, and two departments of computer science (one in Tromsø and one Narvik).Therefore an external review of the organizational structure at the UiT has been initiated and will deliver a report in October 2016.

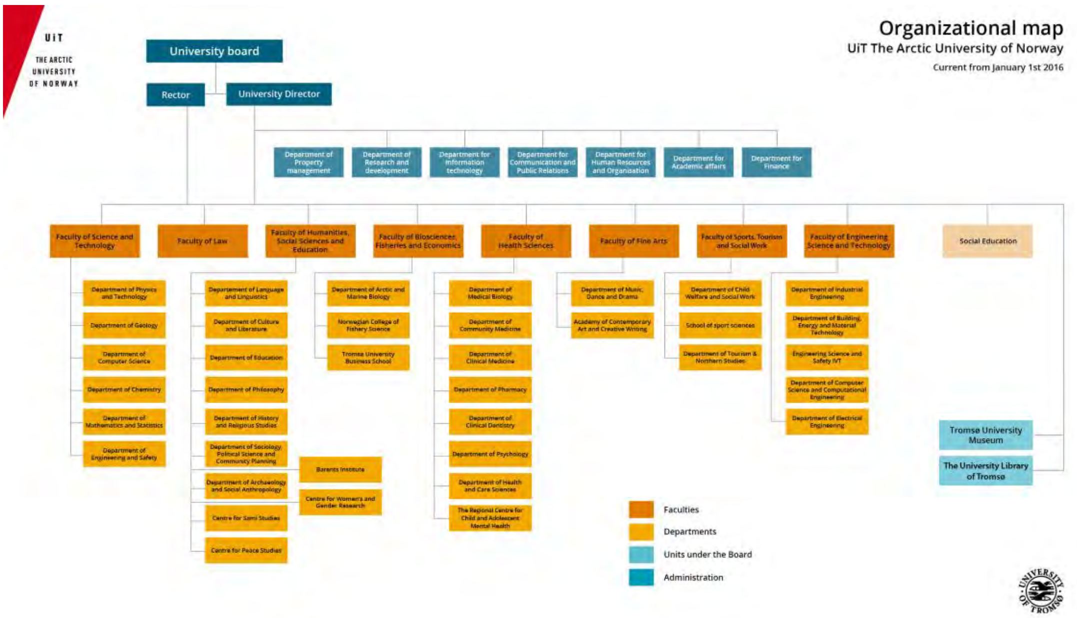

Figure 5 Organizational map of UiT 2016 (UiT 2016).

5. Conclusion

It is too early to determine the level of success of the reorganisation of the Norwegian higher education since the institutions are still in the process of merging.

For the engineering and technology the new structure invites closer collaboration between both technology departments and between technology and (natural) sciences. For the students there are a greater choice of programmes, and it is easier to continue on from bachelor to masters studies.

The growth of UiT is based on merging process. The new national teacher education of five years masters programmes is based on the experiences from UiT.

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Online Quizzes to Increase Student Learning in an Engineering Unit

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Abstract: Due to rapid changes in the communication technologies, the teaching and learning has changed dramatically over the last two decades. The face-to-face (class room based) teaching remains one of the most predominant ways of imparting knowledge to students. On the other hand, different online activities are increasingly being used to supplement traditional face-to-face engagement. In this paper, engagement strategies adopted while delivering one of the civil engineering subjects (units) from Bachelor of Engineering program offered by Western Sydney University are presented. The engineering course includes mathematical manipulation and engineering software learning. In addition, students participate in online in-lecture engagement tool and quizzes, tutorial sessions, group assignments and final exams. While some of the activities in the course such as in-lecture engagement tool and weekly quizzes are online, tutorial sessions are delivered via face-to-face mode. It was found that failure rate was significantly less for students who passed in online quizzes. Thus indicating that online quizzes may lead to deeper understanding of the lecture materials covered under the unit investigated as part of this study.

Keywords: Blended learning, tutorial, face-to-face teaching, in-class engagement, problem based learning.

1. Introduction

Due to rapid changes in the communication technologies, the teaching and learning has changed dramatically over the last two decades. The face-to-face (class room based) teaching remains one of the most predominant ways of imparting knowledge to students. In the face-to-face teaching system the main contact point between teacher and the students is classroom, where students listen to lectures, receive lecture materials and take notes on lectures, and attempt class test and final exams. On the other hand, the online learning is defined as learning that takes place entirely over the internet (Revere and Kovach 2011; Bourne et al 2005). A combination of face-to-face and online delivery systems is called blended learning approach (BLA) and is expected to enhance the learning ability of students (Rahman 2016; Bhathal 2015). In BLA, various learning materials are made available to the students including online availability of recorded lectures and tutorials, hand written tutorial solutions, discussion board and online practice quizzes (Rahman 2016). Blended learning approach is currently practiced in most of the engineering courses in Western Sydney University. Typically, in a blended learning system lectures, tutorials and final exams are classroom centred activities, however quizzes may be online.

Student activities in the class are core to student's learning (Biggs 1999), although it is not straight forward what types of activity will keep the students fully engaged in the class and help in learning. Close associations exists between conception of learning through discussions with approaches to face-to-face and online activities and learning outcomes (Ellis et al 2008). According to Smith et al

(2005), it would be interesting to know if there is any impact of teacher's efficiency in delivering the lecture, underlying complexity of the course content, group based activities, and connection of curriculum with the industry related problem on student engagement in the class. However, Smith et al. (2005) observed that breaking up lectures with short discussion times may have positive impact on re-engaging the students to the lectures. This type of breaking up of lectures can be achieved by implementing various online activities and have received attention by many educators who implemented this type of activities in many engineering as well as non-engineering courses (Dabbour 2016; Carroll 2014; Schultz 2013).

Online quizzes, usually on weekly basis, were found by some researchers an effective method of student learning for mathematics and physics for engineering students (Martins 2016; Bhathal 2016; Blanco et al 2009; Siew 2003). One of the advantages of the online quizzes is that it can save some precious class time and also allows large number of students to be involved in the learning activities with little effort from the teacher (Martins 2016; Broughton et al 2013). However, Lim et al (2012) argued that attending the online quizzes did not improve the students' pass rate in a mathematics unit.

In this paper effectiveness of using online quizzes in an engineering unit, namely, Infrastructure Engineering is assessed. The assessment is based on students' performance in different activities of the unit. Online quizzes have been assessed as a learning tool compared to other conventional face-to-face systems including tutorial, group based major project and final exam.

2. Course content of "Infrastructure Engineering" unit

The *Infrastructure Engineering* unit provides students with material to assist them with Civil Engineering Construction and Urban Development and Town Planning projects. The unit mainly focuses on the planning, design and construction of transportation facilities using a case of subdivision development. As per the learning outcomes of the unit are concerned, upon successfully completing this unit, the students will be able to:

- Apply principles involved in the design, construction and maintenance of both small and large transportation networks comprising of both roadways and railway tracks;
- Analyse and design transportation hubs and intersections for allowing efficient traffic flow;
- Analyse sustainable transport systems and facilities for both rural and urban areas;
- Apply available design tools and guidelines for transportation network design; and
- Create and contribute to productive and efficient teams for designing and evaluating efficient transportation systems.

The teaching and learning activities of the unit are shown in Figure 1 and discussed in subsequent sections. The delivery of this unit is structured on the principles of "Problem Based Learning."

2.1 Lectures

In this unit the lectures are designed to introduce students to concepts relevant to infrastructure and to brief students on assessment requirements. Lectures are mainly delivered using power point slides and document camera. While the concepts are explained using power point slides, step by step solution to examples are shown using the document camera. To check whether the students understood the concepts an engagement tool, namely, GoSoapBox is used.

2.2 GoSoapBox

In the *Infrastructure Engineering* unit, 3-4 questions are asked using GoSoapBox tool during the lecture time depending on the content of the lecture. The questions are generally simple and straight forward type. These questions are mainly intended to test the understanding of the concepts introduced in the lecture by the students. When asked, the students log in to GoSoapBox with an access code given by the lecturer and complete the activity. Through the use of this tool students are able to convey the message that they have either understood or not the concepts introduced in the lecture. On the other hand, it is an instant feedback mechanism on the students' understanding of the lecture materials to the lecturer. Based on the feedback received the lecturer decides on either explain the concept further or move on to the next topic. There is no mark allocated for participating in GoSoapBox.

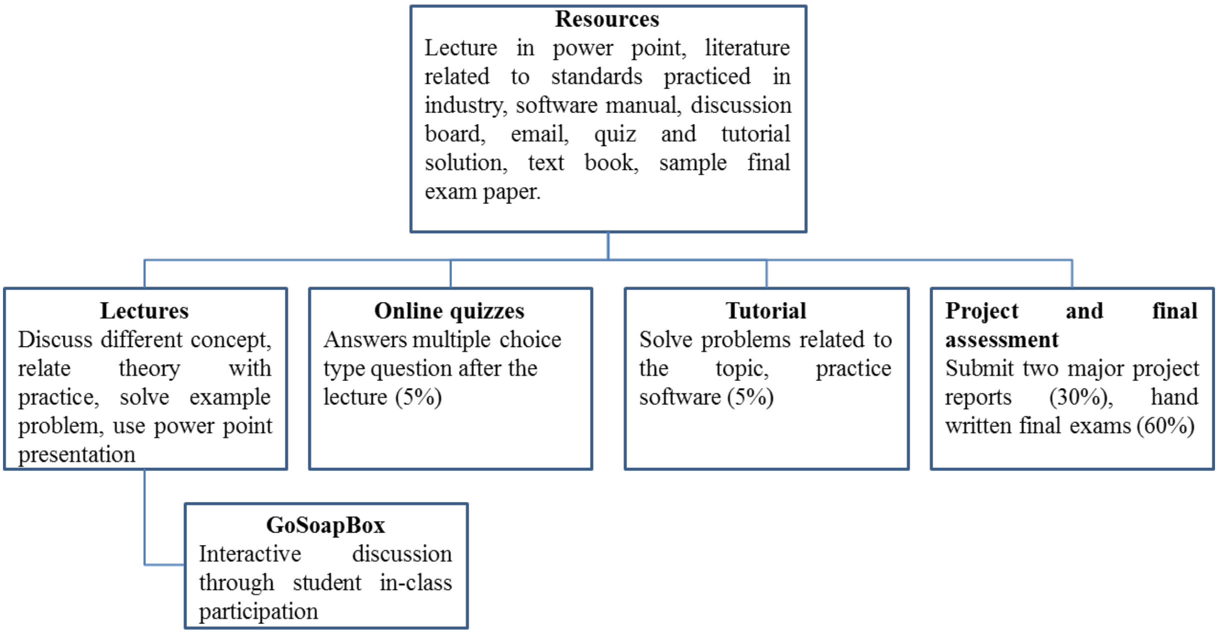

Figure 1 Learning and assessment components of Infrastructure Engineering unit

2.3 Tutorials

In tutorial classes, the students perform activities to reinforce the concepts introduced in lectures. Tutorials are held in tutorial rooms or computer labs where students get chance to work together on their projects and to learn the relevant software. Students are encouraged to participate in tutorial classes by allocating 5% of the total marks for attendance. Each student must answer all the tutorial questions and/or follow the steps to use the software. Tutor, if required, assists individual students for solving the tutorial questions or the use of particular software. Each student is expected to work independently and, at the end of the tutorial class, submit the answers to all the questions or show the output from the software.

2.4 Online quizzes

Online quizzes are in addition to GoSoapBox quiz questions, where students are asked to answer 6-10 questions. These questions aim to test the understanding of underlying concepts of the topic discussed in the lecture. The students need to attempt all 13 online quizzes based on the weekly lectures. The students are allocated 6 days to answer the questions in an online quiz. Students must take these quizzes in order to gain the participation marks for this assessment component. The overall mark for this assessment component depends on the performance of each of the students in each of the online quizzes. For example, if a student receives 100% in each of the quizzes over all 13 quizzes, the student will be credited with 5 marks towards his/her final mark. The students are given feedback on their answer in the following week of each lecture.

2.5 Major project and final exam

Students need to submit two major projects carrying a weighting of 30% and attend final exam. The final exam carries 60% of total marks.

3. Methodology

Data related to students' performance in different activities of the unit were extracted from results of Autumn 2015 session. Regression analysis was performed to find the effect of students' performance in online quizzes on the final marks. Similar analyses were carried out to find the effect of tutorial, major projects and final exams on the final marks. For this purpose linear regression technique was used, which attempts to model the relationship between independent and dependent variables by fitting a linear equation to the observed data. In this study, the relationship between the dependent variable and the independent variables are assumed to be linear. The following represents a multiple linear regression equation (Montgomery et al 2012):

$$Y = \alpha + \beta_1 X_1 + \beta_2 X_2 + \cdots + \beta_k X_k \qquad (1)$$

where, α is the model intercept, $\beta_{1,2,3\ldots k}$ are the slope coefficients, and k is the number of independent variables.

Statistical analyses were carried out using Minitab™ statistical software. Data on students' response on the unit was collected from Student Feedback on Unit (SFU) for Autumn 2015.

4. Results and discussion

In the Infrastructure Engineering unit, the marking criteria were set as *fail* or *unsatisfactory (F)* when student received 0-50%, *pass (P)* for 50-64%, *credit (C)* for 65-74%, *distinction (D)* for 75-84% and *high distinction (HD)* for 85-100% marks. Distribution of students' marks in individual sections of the unit is shown in Figure 2. It can be seen from Figure 2 that students performed well in tutorial and in major projects compared to online quizzes and final exams. In online quizzes, 38% students received less than 50% marks, which is 40% for the final exam. In tutorials and major projects, 12 and 5% students were failed, respectively. Overall, 22% of the students failed in this unit.

Investigation was carried out to see the impact of the students' performance in each assessment component on the final overall marks (Figure 3). As shown in Figure 3, both quizzes (R^2 = 0.25) and tutorial marks (R^2 = 0.13), are positively correlated with the final score, however, quizzes show higher correlation compared to tutorial. In both cases, the predictor variable was significant as the p-value was less than 0.001. The low p-value suggests the predictor as a meaningful entity in the regression equations. Similar observations were made for major project and final exam marks (Figure 3c and 3d). It appears that the final exam was the deciding factor for the final mark of each student.

Weak correlation between tutorial mark and the final mark may be partly attributed to several reasons. Some possible reasons for this may include:

- Often the tutorials are very prescriptive and students fail to pay attention;
- Not much opportunity for students to think;
- Blindly follow the tutor in solving the design problem;
- Marking may not be rigorous.

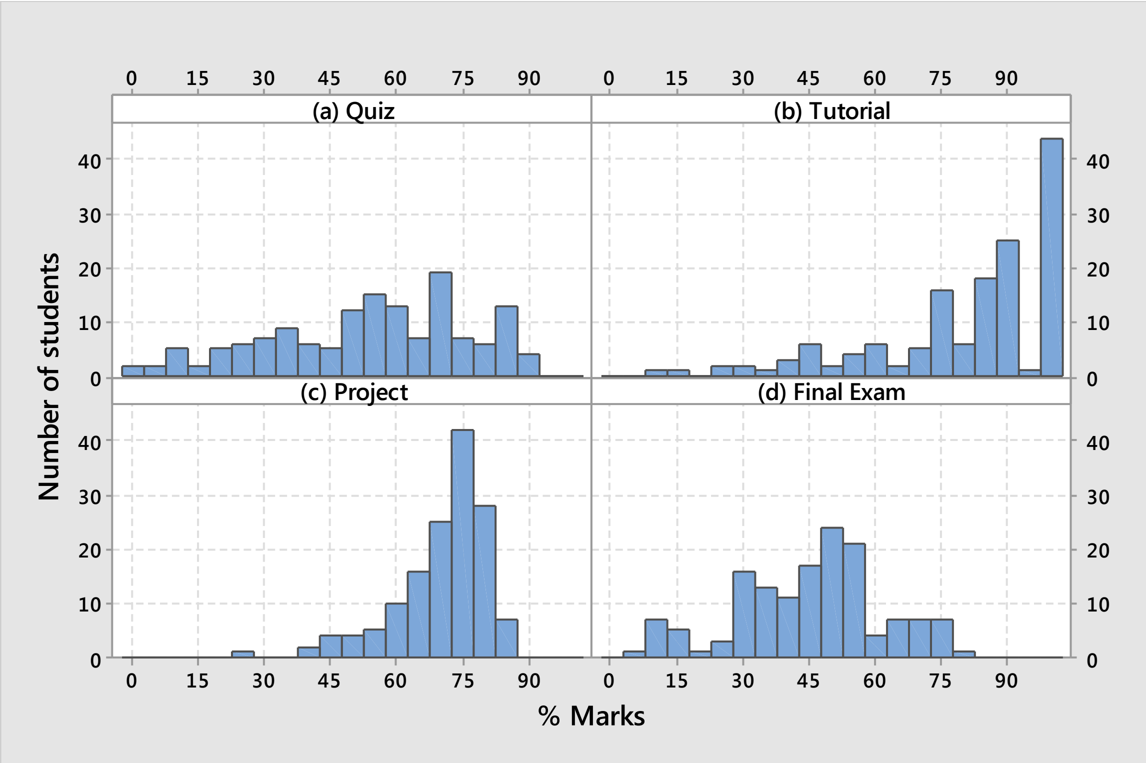

Figure 2 Histogram of students' score in (a) quiz (b) Tutorial (c) major project and (d) final exam

In relation to the last item, the participation mark was given to students as far as they demonstrate the participation in the tutorial activities by showing the completed solution to the particular question. While marking the tutor may not check whether the student has understood the solution method and the basic concepts. This is mainly due to the time limitation that the tutor will have for marking the tutorial papers.

It was interesting to see that students who failed the online quizzes, 31% of them got F as the final grade; only 5% of the students got C and the rest as P. On the other hand, students who passed all the quizzes, only 17% of them got F as the final grade; however, 19% of the students scored C and 12% of the students D. No students scored HD in the unit. The results explain the effectiveness of online quizzes for students' learning. Similar observations were made by Aziz (2003) in an engineering unit (*Computer Systems)*, where students found online quizzes an interesting way of learning. According to Aziz (2003), 70% of the students found the online quizzes useful for testing their knowledge and for focussing on important topics in the course; 58% of the students found the quizzes a more interesting way of learning rather than just attending lectures and tutorials. The data presented in Figure 3 appear to reinforce the above findings of Aziz (2003). The students may find the online quiz an interesting way to learn the subject because of its flexibility. The online quizzes can be done anytime and anywhere. The system provides opportunities to undertake the activity with greater flexibility by students who live long distances from campus, have children or lead busy lives. Many of the students in the *Infrastructure Engineering* work part-time and took the advantage of accessing the quizzes in their preferred time. It is also possible that some of the students may have collaborated with their peers before answering the quiz questions. Similar observation was made by Martins (2016) regarding online quizzes. However, in the current study attempts were made to minimise the possibility of collaboration between peers by presenting the tutorial questions and possible solutions to the questions in random orders. Also in some cases the questions were presented from a bank of questions, which minimised the possibility of presenting the same question between two students.

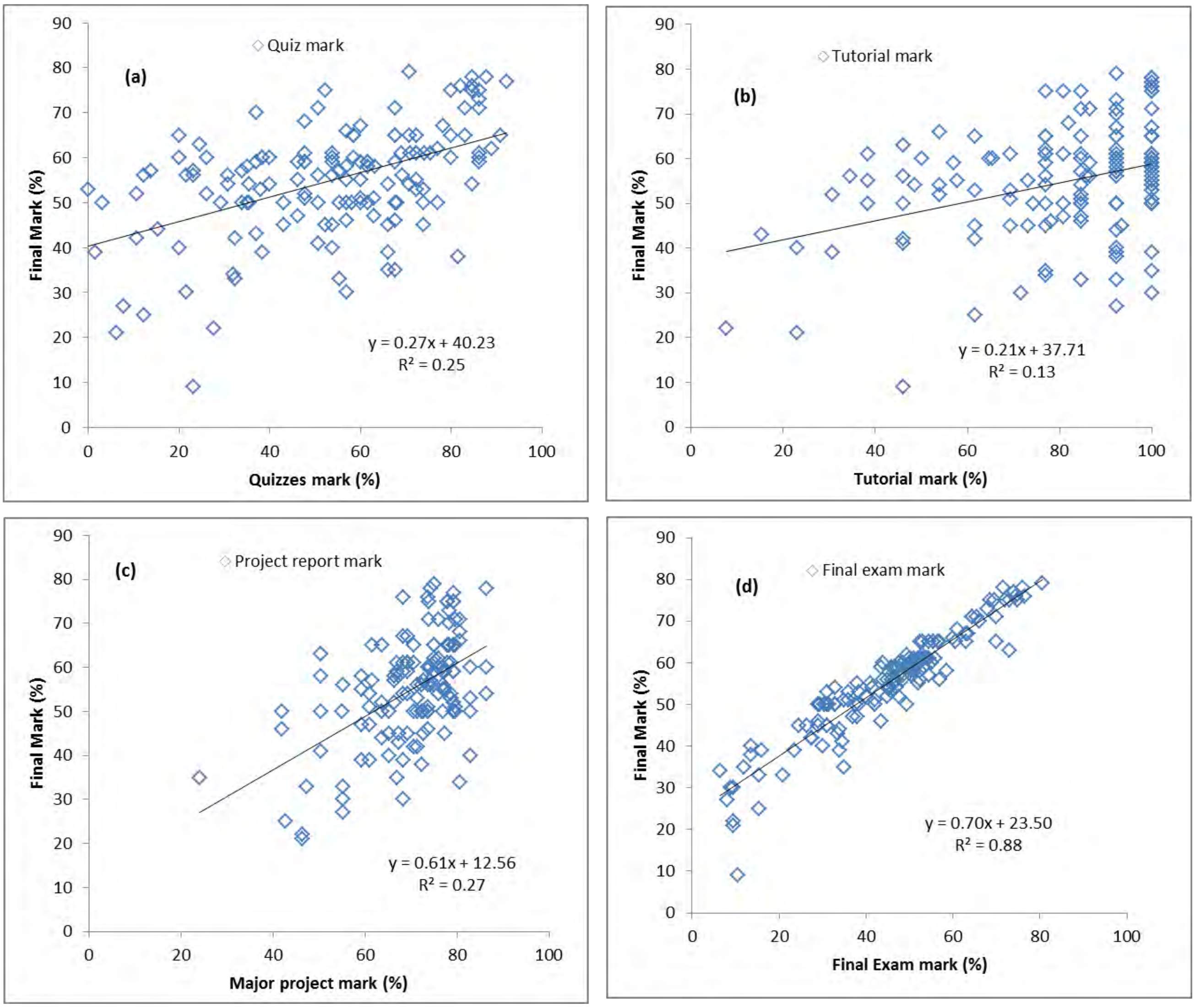

Figure 3 Correlation of students' final score with (a) quiz (b) Tutorial (c) major project and (d) final exam marks

In the case of tutorial, the students who failed the tutorial, 47% of them got F as the final grade and 57% got P. On the other hand, students who passed all the tutorials, only 19% of them got F as the final grade; 16% of the students scored C and 9% of the students scored D. In comparison to online quizzes, higher failure rate was observed who passed all the tutorials; percentages of C and D were also lower compared to online quizzes. Again reasons behind this observation are same those observed earlier, lack of attention during the tutorials and rigor of marking.

To provide more engaging tutorial classes, it is necessary to hands-on sessions such as interactive multimedia software. Dharmappa et al (2000), implemented *multimedia approach*, for teaching fundamental concepts in Environmental Engineering. In the multimedia approach, initially the lecturer introduces the concepts and then the students can use a multimedia software package to reinforce the concepts. According to Dharmappa et al (2000), the students found the animations and simulations included in the package very useful for understanding the underlying engineering concepts. However, students should be willing to accept such interactive as well as multimedia enhanced lectures and manage their time more efficiently to access and practice the software in their own time. This will also save time and money for providing additional classes to learn the software.

5. Conclusions

This study investigated the use of online quizzes and tutorials as tools for students' deeper learning of an engineering subject, and compared with other face-to-face learning activities. Online quizzes showed relatively higher correlation between the mark obtained in the quiz and the final mark. Thus indicating that online quizzes may lead to deeper understanding of the lecture materials covered under the unit investigated as part of this study.

The study provided statistical analysis based on limited data, however, students' performance data from different years will make the analysis more meaningful. The study provided a glimpse of students' response on the unit through SFU. Nevertheless, questions asked in the SFU addressed only general issues related to the unit. Questions in SFU should be more specific to different activities (e.g. quiz, tutorial, major project) practiced in the unit. This will allow students to comment for further developing the unit. Online in-lecture engagement tool (e.g. GoSoapBox™) practiced in the unit, may have impact on the student learning, which needs further investigation.

Acknowledgement

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Engineering Education and Training in Bangladesh: Opportunities and Challenges

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Abstract: This paper presents the opportunities and challenges in engineering education and training in Bangladesh. The engineering education was formally started around 70 years back in Bangladesh. The vision of developing engineering education was set to meet the increasing demand of engineers as the country was determined to develop its industrial sectors and physical infrastructures. In this process, the engineering education system has produced numerous talented and skilled engineers who have played a great role in developing Bangladesh and also worked in many other countries around the globe. However, the universal scenario of engineering education and practice has been changing rapidly with the changes in technology and socio-economic structures. The accountabilities of the engineers are being changed too due to alteration of socio-economic concepts. Due to climate change, the frequency of natural disasters has been increasing both in Bangladesh and other countries. Hence the future engineers need to think and develop new technology to protect the human society from increasing natural disasters. There are 5 public engineering universities along with other private universities in Bangladesh which are focusing on engineering education in Bangladesh to produce engineers who can tackle current and future needs. Engineering Staff College Bangladesh (ESCB), which was established in 2001, has been serving professional and need-based continuing education and training in key areas of engineering. There are many challenges in engineering education systems in Bangladesh, which have been presented in this paper. It is argued that a new curriculum needs to be designed to bring the engineering education in Bangladesh up to the international standard, which is vital for a brighter future of Bangladesh where natural disasters are more common than many other countries.

Keywords: Engineering education, Bangladesh, training, Engineering Staff College, continuing education

1. Introduction

To start with, let us recall the meaning of the terms “Engineering” and “Education”. According to the Oxford Advanced Dictionary, “Engineering means the activities of applying scientific knowledge to design, building and control of machines, roads, bridge, electric equipment etc. The term education means a process of teaching, training and learning, especially in schools and colleges to improve knowledge and develop skills”. Therefore, Engineering Education “would mean the process of teaching, training, and learning in educational institutions for applying scientific knowledge to the design, building and control of machine, roads, bridges and electrical equipment etc. Engineering Education is one of the most potent means for creating skilled and technical manpower required for the development tasks of various sectors of the economy for improving the quality of human life. It incorporates a technological dimension which is a vehicle for development. Engineering education may itself imply high costs, but such high costs, being related to development, should be viewed as an essential production investment, yielding valuable returns to society and contributing to socio-economic development. In engineering education system real-life-problem based learning can be an effective way as it helps students to solve open–ended engineering problems (Edens, 2000). Rugarcia (2000) had pointed out seven features that pose challenges to future engineers, which are as follows: expansion of information, diminishing boundaries between the disciplines, globalized economy, endangered environment, resource constraints, emerging social responsibilities and rapid changes in technology. To cope with changing situation, engineers must have the ability to identify and solve new problems and must understand the impact of their solutions in a global and societal context (Kabir et al. 2008).

The engineering education in Bangladesh has made significant contribution to the overall development of Bangladesh. From a merely agriculture based society, Bangladesh is today moving ahead as a developing country with moderately good industries alongside with a highly developed agriculture sectors. As we are in the first quarter of the 21st Century, it is imperative that our development efforts be supported by the relevant science and technology inputs on one hand and relevant human resources on the other. Engineering Education and Research thus need to play a significant role in the economic scenario of a country. For this, it needs proper re-evaluation and re-orientation to cope with the global development. The objective of this paper is to highlight the opportunities and challenges of engineering education in Bangladesh along with its historical evolution.

2. Development of Engineering Education in Bangladesh

The journey that Engineering Education had to undertake, to come to this present stage is long, arduous and hard, but generally had been successful and pleasant. Its first generation Institution, the Survey School of Dhaka started its journey in 1876, Established by the British Raj, it marked the beginning of technological type of education and training in the Indian sub-continent region. The school was shifted from its old site to the new site in 1908 and was upgraded as Ahsanullah School of Engineering with the provision of technician level engineering education. This was possible due to the willingness of the British Government and keen interest and generosity of Nawab Sir Ahsanullah for which his name was associated with the Institution. Further development took place for the necessity felt to produce high level professional personnel in the engineering field. In 1946, it was decided to enhance the scope of the Ahsanullah School of Engineering to offer degree courses in engineering field. After partition of India in 1947 at the end of British rule, the then East Pakistan Government authenticated the same and thus professional level engineering education began in East Pakistan.

2.1 Engineering University

Degree level engineering education began in Bangladesh (the then East Pakistan) around the time of partition in 1947 by enhancing the former Ahsanullah School of Engineering offering technician level study programs to a College to offer degree courses in Civil, Electrical, and Mechanical Engineering disciplines. The college started with an intake capacity of 120 students and later through further development it was increases to 240 by 1960. The college was affiliated to the University of Dhaka as its Engineering Faculty. By 1960 the college emerged as a well-organized and reputed institution. With a view to organize and develop both the undergraduate program and introduction of post graduate study and research to meet the requirement of economic developments in the country, the Ahsanullah Engineering College was upgraded to the status of University (named Bangladesh University of Engineering and Technology (BUET) on the 1st of June, 1962 by the then East Pakistan Government through promulgation of an ordinance (xxxvi of 1962). Alongside the development of BUET, necessity was felt to extend the facilities of undergraduate level education to other parts of the country. During early 1960's a plan was taken up by the government to set up Engineering Colleges at Rajshahi, Chittagong and Khulna in phases. As a result of this, the first Engineering College was setup at the divisional headquarters of Rajshahi with an intake capacity of 120 students. The next Engineering College was set up at Chittagong in 1968 with an intake capacity of 120 students. The third Engineering College was set up at Khulna and started functioning in 1974 with an intake of 120 students.

The fourth Engineering College named Dhaka Engineering College for higher education for the Polytechnic Diploma holders was set up in Dhaka in 1983. The campus is situated at Gazipur. All the four engineering colleges at Rajshahi, Chittagong, Khulna and Dhaka were previously under the administrative control of the Directorate of Technical Education, Government of Bangladesh. Later, they were upgraded as degree offering institutes named Bangladesh Institutes of Technology (BIT). Now they are Universities. Institution of Engineers Bangladesh (IEB) has established the Board of Accreditation for Engineering and Technological Education (BAETE). BEAETA is going to check the compatibility of the other engineering departments with different universities.

The number of universities in Bangladesh is 103 at present. Almost all of the universities except very few have engineering faculty. Therefore, the number of engineers coming out every year is quite large at present. Since each university has the authority to offer degrees on their own, the quality of graduates coming from the different universities is likely to be different. Institution of Engineers, Bangladesh (IEB) has set up an organization named Bangladesh Professional Engineers Registration Board (BPERB). BPERB occasionally conducts examination for registration of Engineers and those who come out successful are awarded membership of BPERB. They also can write PEng after their name (Such as Engr. ABC PEng).

3. Profile of Engineering Graduate of the 21st (Present) Century

It should be noted that it took from year I AD to 1750 AD to double man's technological knowledge, it doubled between 1900 and 1950, and doubled again between 1950 and 1960. Knowledge quadrupled again in 1970 and again in 1980s. It increased about 10 folds in 90's. Clearly, we are living in an age of ***exponential increase in technology and knowledge***. We need to know more and more about different aspects of technology. A multi-disciplinary background is clearly an asset. In such situation, the engineering graduate of the 21st Century will require the following:

1) good knowledge of broad technical fundamentals and engineering concepts of the chosen and related disciplines, as well as, knowledge in some depth in at least one technical speciality
2) well-developed learning skills
3) good communication, interpersonal and team work skills

4) ability to deal with open-ended multidisciplinary problems
5) understanding of the principles and responsibility of leadership
6) exposure to the design and implementation requirements of integrated interdisciplinary projects
7) basic knowledge of principles of management, economics, finance, business, sustainable development and environmental protection
8) knowledge of the basic principles of project, human resources and time management
9) understanding of the requirement to maintain continued competence and to keep abreast of up-to date tools, techniques and practices
10) exposure to concepts of ethical practice, responsibility and accountability
11) exposure to issues of social and environmental responsibility as related to the practice of engineering
12) exposure to the concepts of change and change management
13) exposure to the issue of cultural and business practice differences and their impacts on professional engineering practice

Engineering education must offer the students a compelling context for engineering design, a multidisciplinary team experience, and sufficient time to learn and practice professional skills, personalized mentoring and exciting technical challenges (Coyle et al., 2005).

4. Engineering Staff College Bangladesh (ESCB)

To meet new challenges, Engineering Staff College of Bangladesh (ESCB) was established in 2001 as a corporate body of the Institution of Engineers, Bangladesh (IEB) with a vision of human resources development for building better world and mission to perform as a centre of excellence for professional development. It is administered by a Board of Governors (BOG) responsible to the council of IEB. The executive and academic head of ESCB is Rector who is appointed by the Council of IEB on the nomination of BOG. The primary objectives of ESCB are to impart professional and need-based continuing education and training in frontier areas of engineering, management and technological fields, simultaneously providing professional consultancy/advisory support and technical and management services to the industry and relevant government and private organizations.

ESCB maintains a list of experienced professionals and skilled technical personals, related to procurement, engineering, ICT, social infrastructure and advisory support etc. ESCB is adequately equipped with required logistics of transports, IT and e-GP laboratory, LAN, server and personal computers etc. ESCB holds a library containing a wide variety of engineering and management reference. ESCB owns its main campus on 23.5 acres of parkland near Dhaka-Chittagong Highway 40 km away from Dhaka City. ESCB has also a campus in the Head Quarter of IEB in Ramna, Dhaka-1000. ESCB has been actively participating in Bangladesh Government and Non-Government projects in the area of training and advisory supports. ESCB has a Procurement Faculty, consisting of Dean, Senior Procurement Trainer and three other competent procurement trainers. Public Procurement Management program has been undertaken in ESCB since 2005 with its limited resources, and since 2008 Public Procuring Entities are being imparted training under World Bank financed PPRP-II and PPRP-II AF Projects. e-GP (Electronic Government Procurement) has been introduced recently. Projects for such training programs are implemented by ESCB with other organizations.

In response to ESCB's approach for training program in PPR and electronic government procurement, e-GP, government agencies like Power Sector Capacity Development Project (PSCDP) of Power Division, Ministry of Health and Family Welfare, SEQAEP and HEQEP of Ministry of Education, Planning Division, Ministry of Planning, Policy Support Unit of LGD of MOLGRD&C, Bangladesh Agriculture Development Corporation, National Board of Revenue, Institute of Charted Accountants of Bangladesh, Education Engineering Department, Bangladesh Police and other organizations chose ESCB for their training programs on PPR, e-GP and other relevant matters.

ESCB is implementing the course for Diploma in Procurement and Supply of the Chartered Institute of Procurement and Supply (CIPS), UK since May, 2013. The Certificate Program in Public Procurement (CPPP), launched by the World Bank is a crying need in this part of South East Asia. CPPP which is an integral part of the larger Professional Diploma in Public Procurement (PDPP) is to be delivered in Bangladesh by ESCB as partner institution of the World Bank.

4.1 Training program to Engineers from ESCB

ESCB undertakes training programme on:

- Programming of PLC for Industrial Automation, Maintenance and Troubleshooting
- AC Inverter Drives
- Electrical Machines Operation, Maintenance & Trouble Shooting
- Pile Foundation: Design and Construction
- Computer Aided Analysis and Design of Buildings & Foundation and Slab using ETABS and SAFE software
- Fire Fighting System, Fire Detection System & Fire Safety Assessment
- Plumbing Technology
- Fire Safety in Buildings
- Instrumentation and Control Engineering
- Computer Aided Project Management using Primavera and Microsoft Project
- HVAC (Refrigeration and Air Conditioning)
- Seismic Design and Construction of RC structures
- Computer Aided Analysis and Design of Civil Engineering Structures using STAAD. Pro Software
- Occupational Safety, Health & Environment Management
- Microcontroller
- Electrical Services for Buildings and Industries
- Introduction to Building Construction Regulations and Bangladesh National Building Code
- Captive Power Generation
- Siemens S7-300 & S7-400 PLC

ESCB's selection as a partner organization in MOOC is an important event and hopefully it will be a hub of professional training in procurement and other related areas. Besides these, ESCB tries its best to conduct training programs for an organization by using relevant experts of the respective fields.

5. Conclusion

The impact of the changes in the global and national economic scenarios is bringing an era of global consciousness. This global consciousness prevailing in other developed countries would very much put a pressure on small and developing countries like Bangladesh. Every effort for our survival should be made to understand it and prepare ourselves in terms of quality of technical education and manpower. The industries require among, other things, workforce having a scientific bent of mind to possess the much desired temper and skills to maintain high quality and productivity at par with the world standards. The R & D efforts should also be geared up commensurately, the science and technology education and research have, therefore, to respond to these emerging challenges to train men and women of calibre and competence of the world standards and provide the needed R & D capability. In addition, the explosion of knowledge in science and technology sectors requires highly talented men and women whose fast grasp of knowledge could enable them to respond to the desired innovations in advancing the frontiers of knowledge and knowhow. However, the success in this regard will depend upon the abilities to cope up with the emerging pressures of resources crunch on the one hand and the need for up gradation of the quality of science and technology education and research on the other, through proper reorientation. To cope with the rapid changes in engineering practice, renowned international universities are regularly going through the evaluation of courses as well as adoption of new delivery modes, the Engineering Universities of Bangladesh should also follow this suit so that they can create multidimensional, competent and conscious engineering graduates who will eventually lead the nation to a new stage of development.

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FI3D: An Anticipatory Space

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Abstract: The concept of "anticipatory space" emerges as part of a research project at the Computer Science School of the National University of La Plata (UNLP), to refer to a computing resource that allows users to take a virtual tour of the premises of the School. While this resource was intended for a general audience to virtually visit the solar panels that supply a percentage of the power consumed by the entity, installed on the terrace, it became apparent that there was a potentially beneficial use of this resource in the service of future students and their families. Annually, more than 800 students are admitted to School programmes. Most of them have never visited the school or its surroundings. Tools like Google Street View can provide an overview of the surrounding area but not inside the facility or its particular characteristics.
This paper provides an overview of FI3D, a first prototype of an “anticipatory space”, as well as the evolution of this concept to a space that incorporates the resources necessary to not only interact with space to obtain information from it, but also provide educational tools associated with the training of future students.

Keywords: Anticipatory space, 3D environments, Blender software, open source

1. Introduction

The concept of “anticipatory space” was put forth by Javier Díaz[1] in 2014. In the framework of a research work, he used this term to refer to a computing resource that would allow users to take a virtual tour through the premises of the Computer Science School[2] of the UNLP[3] .

Although the development of the resource was fostered by the need to have a tool that would allow the School to show the general public the new solar panels supplying a percentage of the power consumed by the entity, installed on the terrace, the potential of the use of this resource in the service of future students and their families became apparent from the beginning. This new consideration led the purpose of the resource to expand and include not only showing the solar panels of the School but also sensitizing the general audience in general, and future students in particular, regarding the features of the premises.

This context results in the first definition of the concept of anticipatory space, “*a virtual 3D space representative of a particular physical space, created and designed with the purpose of allowing access for a user to go over it, know it and become sensitized with it. This virtual space, a faithful*

[1] Director of the New Information Technologies Research Laboratory of the Computer Science School of the UNLP

[2] http://www.info.unlp.edu.ar/

[3] http://www.unlp.edu.ar/

copy of a real physical space, will allow any person to 'anticipate' the place where they will engage in a future activity".
In response to this requirement, FI3D (3D Computer Science School) was developed as the first prototype of this space (Banchoff et al, 2015).

FI3D makes use of an avatar representing the user within the environment. Through movements driven by the keyboard, the user "moves" around the building they wish to visit, observing the places that make up the premises and storing images of them in their memory. The user can observe where the different dependencies are located, as well as common areas such as the library, the PC room, the cafeteria, and the classrooms, as well as use the stairs to access higher floors.
A person planning to visit the real School, e.g. a prospective student, will have kept in their memory the images of the multiple places they have virtually visited by using this resource. When the time comes to make a real visit, they will be able to search their memory for images that will allow them to find the premises familiar to them.

Having the posibility of becoming sensitized with a place before visiting it helps avoid feelings of anxiety or anguish produced by the insecurity of facing the unknown, the uncertain or the unforeseeable.(Valenzuela 2011).

FI3D is an anticipatory space because it is a 3D virtual space representative of the Computer Science School of the UNLP that was created and designed with the purpose of allowing access to go over it, know it and become sensitized with it. It is a faithful copy of the real physical space and constitutes a tool that allows persons that will visit the School in the future to "anticipate" it and become aware of the space they will go through.

2. Emergence of the Concept of "Anticipatory Space"

The Computer Science School of the National University of La Plata (UNLP) is an institution offering multiple programmes such as B.S. in Systems, B.S. in Computer Science, University Programming Analyst and Computer Engineering. This last programme is offered together with the School of Engineering of the UNLP. Because of its distinctive features related to the fact that it is a public, free and prestigious institution, between 800 and 1000 students register in its programmes each year.

In 2013, the School, through the LINTI[4] (New Information Technologies Research Laboratory) and its director, Javier Díaz, then also Dean of the School, began thinking of a sustainable way to supply power for the building. Thus, the idea emerged to use a renewable resource as is solar power, a non-contaminating source that has no impact on the environment. For this purpose, solar panels were installed on the terrace of the School using an iron structure, in order to generate over 20 percent of the monthly energy used by the academic unit. The panels are italian crystalline silicon modules made up of 60 cells of approximately 1.7 meters high and 1 meter wide. They are 72 panels generating an approximate power of 15 kWp (kilowatt-peak), each producing around 235 watt peak / 30 volt. Nestor Castro, a teacher of the Computer Science School in charge of the project, explained the mechanism thus: "solar radiation (light) impacting the fotovolcaic modules is converted into an electrical current by means of an electronic process. Both energies coexist,

[4] LINTI. New Information Technologies Research Laboratory. Computer Science School, National University of La Plata. http://www.linti.unlp.edu.ar/

therefore this fotovoltaic system cannot be used as a back-up in case of a power cut in the conventional supply grid and it cannot be used in the night hours”[5].
After installing the solar panels, the LINTI began trying to find a way to promote these projects. It was in this context that the idea of enabling anyone to see the premises without being present emerged.

In 2014, in the framework of a work meeting, the concept of “anticipatory space” is put forth by Javier Díaz to refer to “a computing resource that will allow users to take a virtual tour of the Computer Science School of the UNLP with the goal of reaching the terrace and visiting the solar panels installed there”. Although that was the initial goal of this resource, it later became apparent that it could be very useful for future students and their families. Since not all prospective students reside in La Plata, the tool used to walk around the School was deemed useful for future students, especially those from other cities, to visit the place where they will study for the following years. Being able to visualize the premises before visiting them allows students to become sensitized with the place, avoiding the feelings of uncertainty and fear brought about by arriving somewhere unfamiliar.

FI3D emerged from this proposal as the 3D version of the Computer Science School that allows users to take a tour of the premises with a basic level of immersion.

3. FI3D: The Computer Science School in 3D

The Computer Science School of the UNLP was created in 1999. As previously mentioned, some programmes taught in it welcome between 800 and 1000 new students per year, many of them from different parts of the country and neighboring countries.

In order to obtain information regarding the geographical area where the School is located, any Internet map can be used, such as Google Map[6] or OSM[7]. FI3D, a 3D model representing the institution, was built to complement and extend the information given by a map and to use it in the many projects shared with high school students, potential students or School visitors.

FI3D provides a 3D environment based on the structure of the School premises. Basically, it allows users to take a virtual tour through the classrooms, offices and gardens using an avatar. As previously mentioned, this software does not include any additional functionality, only the tour for the goal of providing awareness of the multiple spaces.
FI3D is free software – the models and development tools involved, as well as the final product are published with free licenses.

Figure 1 shows a capture of FI3D, showing the inner courtyard of the School with the access ramp.

[5] La Facultad de Informática cuenta con la instalación de paneles solares conectados a la red eléctrica más grande del país. Accessed via http://goo.gl/EY21Lx on 12 May 2016.

[6] The Computer Science School on Google Maps: https://goo.gl/fscXoy

[7] The Computer Science School on Open Street Map: http://goo.gl/Wqh5wy

Figure 1 FI3D: External view

3.1. Blender: The Application Model and Engine

As mentioned earlier, one of the goals set was using free sofware for all the stages of development. This entailed another research work around these tools and real use possibilities. Multiple alternatives were analyzed, and Blender was chosen .This entailed another research work around these tools and real use possibilities. Multiple alternatives were analyzed, and Blender[8] was chosen .

Blender has been a widely used tool for several years. It allows for 3D and 2D modeling, animating, simulating, rendering, compositing, motion tracking and videogame creation. Although Blender is a tool for creating applications without writing code lines in a programming language, it provides an API (“Application Programming Interface”) (Blender, 2016) containing the functions and modules that can be used by another software. This APLI allows not only for the codification of the scripts composing the application, but also a customized tool and an extended functionality. The API provides two modules that are important for its use: BGE ("Blender Game Engine"), offering features that allow access to elements composing the application under development, and BPY ("Blender Python"), allowing access to data, classes and functions of Blender itself, in order to create new elements and modify the environment provided by the tool.

Although at first this tool was to be used for modeling the necessary resources, it was decided that the development would continue in the same environment.

Figure 2 shows some screen captures of FI3D and the real spaces after which it was modeled.

8 Blender official site: https://www.blender.org/

Figure 2: Screen captures of different areas in FI3D next to the real-life areas they represent.

Blender was chosen for two main factors: first and foremost, it is free software and there is a large community behind it and a great amount of sources available. This was crucial, given that this development could be used as a basis for other applications, which would mean that both the resources and the software should be available for extensions by the same working group or by other people. The second factor had to do with the fact that Python is the scripting language used. The weight that the programming language had in the choice of tool was due to the experience the developers already had with it and the fact that they have been teaching the Python Language Seminar at the School for years.

The model of the final version used includes:

- The staircase leading to the main entrance to the building.
- The lobby, library and hallways of the floor where the classroom doors are.
- The staircase leading to the second floor. Access to this section is possible manually, leading the avatar step by step.
- The second floor lobby and lateral hallways.
- The PC room in the first floor and its access.
- The staircase leading to the terrace.
- The terrace of the building with the solar panels.
- The inner courtyard behind the library and the open spaces around the cafeteria.

The doors that lead to spaces that have not been modeled in this first stage, such as some classrooms and administrative offices, remain “closed”.

4. An Evolution of the Concept

FI3D is an anticipatory space that allows the user to take a tour of the Computer Science School premises in order to gain awareness of the place and, when the time comes to visit them in real life, provide a sense of familiarity and avoid the impact of entering an unfamiliar place.

Currently, the FI3D resoure only allows the user to go over the premises using an avatar, gaining awareness of the place. By doing so, they can register the distribution of the classrooms, as well as the location of the multiple departments and administrative offices, the library, the cafeteria, and others.

In its current development, FI3D can be considered a basic or level 1 anticipatory space, as it is a mono-user system where the only interaction with the environment is the free circulation offered, but with no possibility of intervening and modifying the environment.

Given the features of the tool, it could be improved to serve as an educational resource to benefit new students. For example, if the current environment is added information related with the functions of each department, the potential student using the resource could not only retain the physical location of the offices and classrooms but also the general way in which the institution works. Thus, they would be interacting with the space and learning about new aspects related to their future university life (Valenzuela, 2011).

5. Conclusions

It is important to emphasize that the general proposal for a virtual tour of the Computer Science School facilities not only resulted in the development of a computing resource that serves the purpose, as is FI3D, but also in the introduction of the new concept of "anticipatory space".

The concept came up when considering broadening the range of use of FI3D so that it not only served the initial goal but could also be used to inform potential new students regarding the entity.

Generally, the process of entering university entails uncertainty and fear in new students. Providing them with an "anticipatory" view of the place they will pass through in the next year is quite beneficial and offers a first step in the process of sensitization.

The development of FI3D was the first step to extend this tool and promote other projects based on this same environment. Currently, two masters theses are under development taking both FI3D and the concept of "anticipatory space" as a basis and extending it in two different applications:

- **TIVU Virtual**, a serious game that encourages the use of anticipatory space for future students of the University;
- **ProBOTs 3D**, a 3D learning environment to teach programming to children and teenagers with free tools.

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On-line Assessment to Promote Engagement and Retention in Engineering Mathematics.

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Abstract: At the University of the West of England (UWE) we deliver a level 1 module, Engineering Mathematics, to a diverse cohort of over 300 students. Module results prior to 2014 indicated that rapid feedback mechanisms were required mid-year to identify early those students at risk of failing in order to provide timely support.
Since 2015 module engagement has been measured through weekly tests which are run as homework. To attain maximum marks, each test must be attempted before an engagement cut-off date. Test scores can be improved throughout the year and multiple attempts are permitted. In addition, we run an on-line January examination to test students' understanding of the first term's work.
We use the DEWIS e-Assessment system to run the weekly on-line tests and the online examination. DEWIS is a fully algorithmic open-source e-Assessment system which was designed and developed at UWE. It is a completely stand-alone web based system used for both summative and formative assessments. This algorithmic approach enables the separate solution, marking and feedback algorithms to respond dynamically to a student's input and as such can perform intelligent marking. A major advantage to running the January exam on-line, as opposed to running a traditional paper-based exercise, is that students receive rapid feedback on their work, because their submissions are marked immediately. Also academics can quickly identify those students that are at risk on the module, enabling them to specifically target such students at a point where interventions are likely to yield positive results.
We describe the methodology of the approach and the impact with respect to overall student performance.

Keywords: On-line assessment, Rapid feedback, Engineering Mathematics

1. Introduction

Engineering Mathematics (EM) is a level 1 module delivered to a large and diverse student cohort. The students study a range of engineering degrees (Mechanical Eng, Aerospace Eng. Automotive Eng. Electronic Eng. and Robotics) and have a diverse range of entry qualifications. A-level mathematics is a required pre-requisite for entry of all undergraduate engineering degrees at level 1, and a substantial proportion of students enter with equivalent qualifications such as BTEC, Foundation Engineering degrees, Access courses and international qualifications. Typical entry requirements from different qualifications can be found at http://courses.uwe.ac.uk/H403. The delivery of the EM module can be loosely described as consolidating mathematical content in semester 1 and teaching new material in semester 2. It is important to ensure that weaker students are keeping up and stronger students remain engaged. On-line assessment has provided a useful tool to measure student performance throughout the year-long delivery. On-line assessment in mathematical and numerate subjects is standard practice in many universities; see Sangwin, (2013). Its use has evolved from being merely summative to formative assessments that give high quality feedback from

which students actively learn; see Greenhow and Gill (2008), McCabe (2009).
In order to promote engagement and improve attainment, we have changed our implementation of on-line assessment over the past few years. The implementation has changed in two radical ways through (i) a move to DEWIS, the e-assessment system that we use to deliver on-line assessment and (ii) the delivery pattern of on-line assessment which has evolved to include not only uncontrolled conditions (coursework) but also controlled conditions (examination). DEWIS and the evolving on-line assessment delivery pattern are both described in section 2. In section 3, the results and impact of the different delivery scenarios are given and some conclusions are drawn in section 4.

2. Methodology

2.1 Overview

Engineering Mathematics (EM) is a 30 credit module making up a quarter of the credit for level 1. Students learn mathematics techniques that will support their engineering studies, including learning to programme in Matlab. As well as the Matlab weekly PC sessions in semester 1, all students receive 2 hours of lectures, supported by a one hour tutorial each week. In addition all students have a scheduled weekly 2 hour Peer Assisted Learning (PAL) session, (see Falchikov, 2001) run by level 2 PAL tutors and which offer whole programme support, not just help with EM. Attendance at lectures and other contact sessions is not compulsory. The module is assessed through coursework (25%) and examination (75%). The coursework is designed to encourage engagement. The Matlab assignment comprises 50% of the coursework mark. E-assessments delivered throughout the year comprise the remaining 50% coursework mark.

2.2 DEWIS E-Assessment System

We moved to the DEWIS e-assessment system in 2009-10. DEWIS is a fully-algorithmic open-source e-Assessment system which was designed and developed at the University of the West of England by Rhys Gwynllyw. Gwynllyw is a mathematics lecturer and software engineer who built the e-assessment system using sound pedagogic principles. In generating a question, question parameters are randomised and generated at the point of delivery.

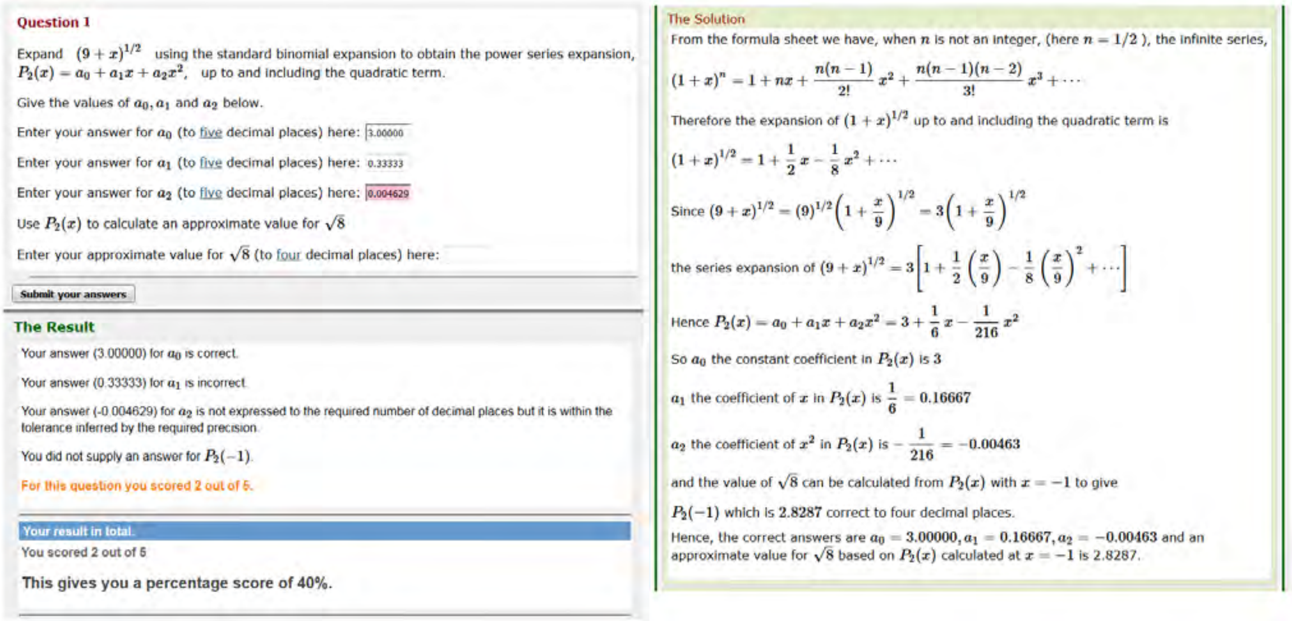
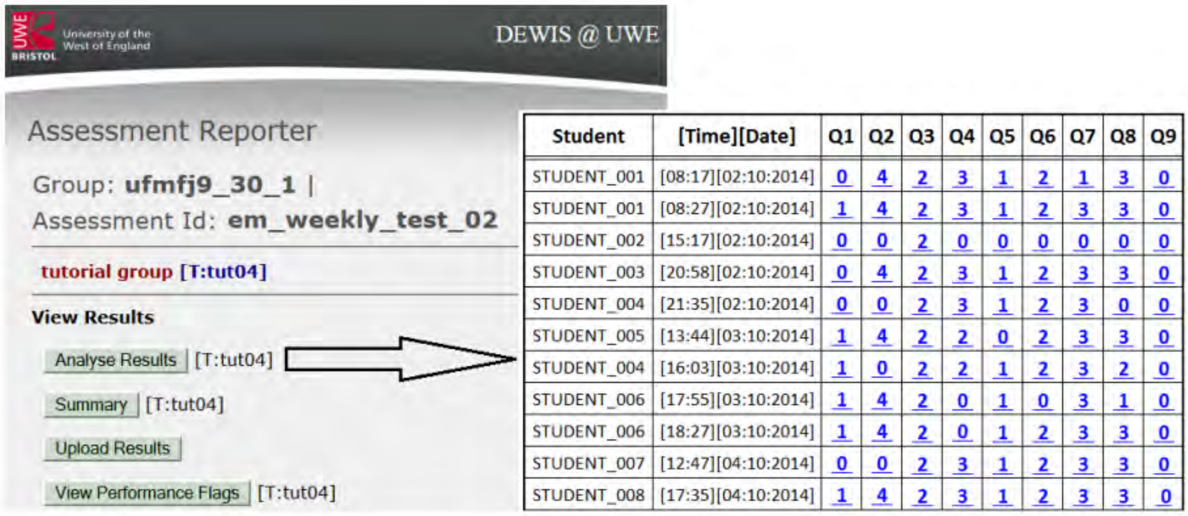


Figure 1: An example DEWIS question, together with feedback bespoke to the random parameters used in this question.

Therefore no two students receive exactly the same question and a student can practice the same question several times with different parameters in order to gain mastery. All DEWIS questions have full feedback bespoke to that question and its specific randomly generated parameters. The feedback not only gives the correct answer but also a fully-worked solution showing how that the correct answer was evaluated. An example of a DEWIS question and feedback is given in Figure 1. Several different types of questions can be delivered with integer answers, real numbers within a prescribed tolerance answers, string answers (used in calculus questions), vector and matrix answers being the most common used in EM. A description of DEWIS with core question-type examples is found at http://dewis.uwe.ac.uk/

DEWIS has a highly developed reporting system which enables tracking at module cohort level, tutorial group level and individual student level. Tutorial group reporting enables tutors to track tutees' progress both overall in an assessment test and at question level. Figure 2 shows a reporting session for a tutorial group, in this case viewing the mark awarded for each individual question in the test. Each mark is a web link, which contains the realisation of a particular question as delivered to that student, the student's answer and the resulting feedback given to them.



Student	[Time][Date]	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9
STUDENT_001	[08:17][02:10:2014]	0	4	2	3	1	2	1	3	0
STUDENT_001	[08:27][02:10:2014]	1	4	2	3	1	2	3	3	0
STUDENT_002	[15:17][02:10:2014]	0	0	2	0	0	0	0	0	0
STUDENT_003	[20:58][02:10:2014]	0	4	2	3	1	2	3	3	0
STUDENT_004	[21:35][02:10:2014]	0	0	2	3	1	2	3	0	0
STUDENT_005	[13:44][03:10:2014]	1	4	2	2	0	2	3	3	0
STUDENT_004	[16:03][03:10:2014]	1	0	2	2	1	2	3	2	0
STUDENT_006	[17:55][03:10:2014]	1	4	2	0	1	0	3	1	0
STUDENT_006	[18:27][03:10:2014]	1	4	2	0	1	2	3	3	0
STUDENT_007	[12:47][04:10:2014]	0	0	2	3	1	2	3	3	0
STUDENT_008	[17:35][04:10:2014]	1	4	2	3	1	2	3	3	0

Figure 2. Tutorial group and individual marking. (Student details have been anonymised.)

Results from student surveys show that students use the e-assessment questions as a learning tool, practicing certain questions many times. This is supported by individual student comments, DEWIS data and research by others, (Greenhow and Gill, 2004).

2.3 E-assessment Delivery Implementation

We have used e-assessment software at UWE since 2000 and migrated to the DEWIS e-assessment system in Engineering Mathematics in 2009. Over that time we have built a substantial library of DEWIS questions to support the teaching of engineering mathematics. The question library resource has enabled us to try out different delivery patterns of e-assessment in order to improve year-long student engagement with the module and hence improve attainment levels. Before 2014, students took six e-assessment tests at regular intervals, three in semester 1 and three in semester 2. Students were allowed multiple attempts at practice tests before taking the equivalent summative assessment test. The practice tests were open from the beginning of term, and closed the day before the assessment test opened. The assessment test was open for 11 days and students could have up to three attempts with the highest score counting. Assessment for the module was completed by an end-of-year written examination worth 75% of the module mark. Module results for 2013-14 are shown in Table 1.

The cohort performance in the examination is much worse than in the coursework and it seems highly likely that the coursework mark did not truly reflect students' progress and ability. Attendance records show that tutorial attendance was 50% on average.

Table 1: 2013-14 Module marks: Coursework 25% (Matlab assignment 12.5%, on-line assessments 12.5%), Summer Examination 75%

	Attempts	Average Mark	Pass rate
Coursework	295	73.3	89.5
Examination	284	50.4	62.7
Module	297	56.1	66.0

In 2014-15, in order to improve the module pass rate and student attainment levels, we implemented a programme to improve student engagement. In particular, we wanted a reliable early warning to alert us to students experiencing difficulties so that supportive measure could be put in place in time to prevent failure. We changed the e-assessment in two main ways. The practice tests were replaced by small weekly tests. Tutors monitored how their tutees were doing in these weekly tests and contacted those students who were either not doing the tests or were not attending tutorials. The marks from the weekly tests did not count. An e-assessment test made up from a selection of questions from the prior 3-4 weekly tests was delivered at regular intervals as in 2013-14 and these marks counted towards the coursework mark in the normal way. In addition, a January exam was introduced, delivered on-line using a selection of questions from the 12 weekly tests of the first semester. This exam counted for 30% of the total examination mark. The remaining 70% examination mark came from a written 2-hour summer exam. The January exam was run under controlled conditions with proper invigilation. As DEWIS is a web-based system, specific security measures were put in place to prevent cheating. More details concerning the running of an on-line examination to a cohort of over 300 students is found in Henderson et al. (2015). Module results for 2014-15 are shown in Table 2.

Table 2: 2014-15 Module marks: Coursework 25% (Matlab assignment 12.5%, on-line assessments 12.5%), Examination 75%, (January On-line examination 22.5%, Summer written examination 52.5%) .

	Attempts	Average Mark	Pass rate
Coursework	300	76.9	91.7
Examination	298	66.5	77.5
Module	302	69.1	80.1

Whereas module results have clearly improved, a closer analysis of results revealed that the six regularly spaced e-assessments were not giving a good indication of student performance. Figure 3 shows that there is a significant proportion of students who scored above 40% average in the e-assessment tests but failed the January e-examination, scoring below 40%. In fact, many scored less than 20%, even though all the questions in the January examination had been seen already in the weekly tests in semester 1.

Therefore in 2015-16, we decided to remove the six e-assessment tests and replace them with a coursework mark based on regular engagement with the weekly tests. The e-assessment coursework mark is made up from the top 20 test marks from the 22 weekly tests – twelve in semester 1 and ten in semester 2. All semester tests are open from the beginning of the semester and remain open until the end of semester 2. Each test is worth 2 marks derived from an engagement mark and an attainment mark. The engagement mark is either one or zero. One mark is awarded if the test is attempted and a mark of at least 40% attained before the test engagement cut-off date, (a full week after the week's lecture delivery). Hence for material covered in lectures in week 1, weekly test 1 has an engagement cut-off time of 09:00 Monday week 3. The attainment mark (out of a maximum of 1) is the equivalent to the percentage mark attained. This mark can be improved at any time up until the end of semester 2. Hence it is possible to score very highly in the e-assessment coursework but

only if the student is committed to a serious attempt of the on-line tests every week.
As in 2014-15, tutors monitored how their tutees were doing in the weekly tests and contacted those students who were either not doing the tests or were not attending tutorials. The e-assessment January examination was run in the same manner as in 2015-16.

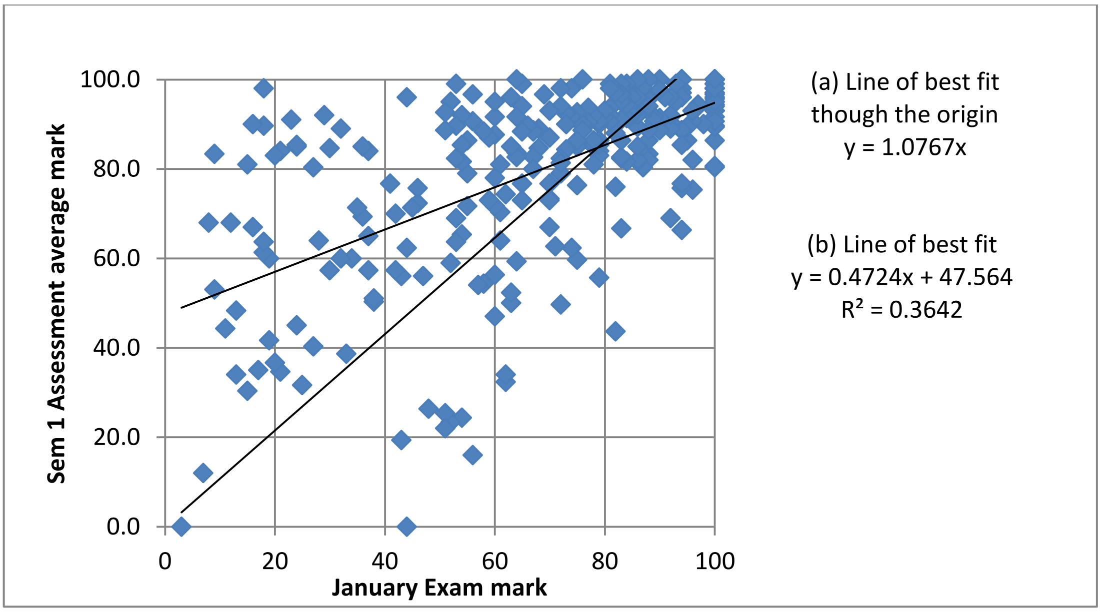


Figure 3 Semester 1 e-Assessment Test Results versus Jan Examination results 2014-15.

3. Results and Impact of Different Delivery Patterns.
Although we know that students like on-line testing and use it support their learning, we were disappointed to see that many students failed the January exam even though they had done well in the assessment tests leading up to it, see Figure 3. In 2015-16, we delivered on-line assessment coursework as small homework-type tests, involving engagement marks and attainment marks as described in section 2. The correlation between the homework-type weekly on-line tests and the January on-line exam shown in Figure 4 is similar to the correlation for 2014-15 of Figure3.

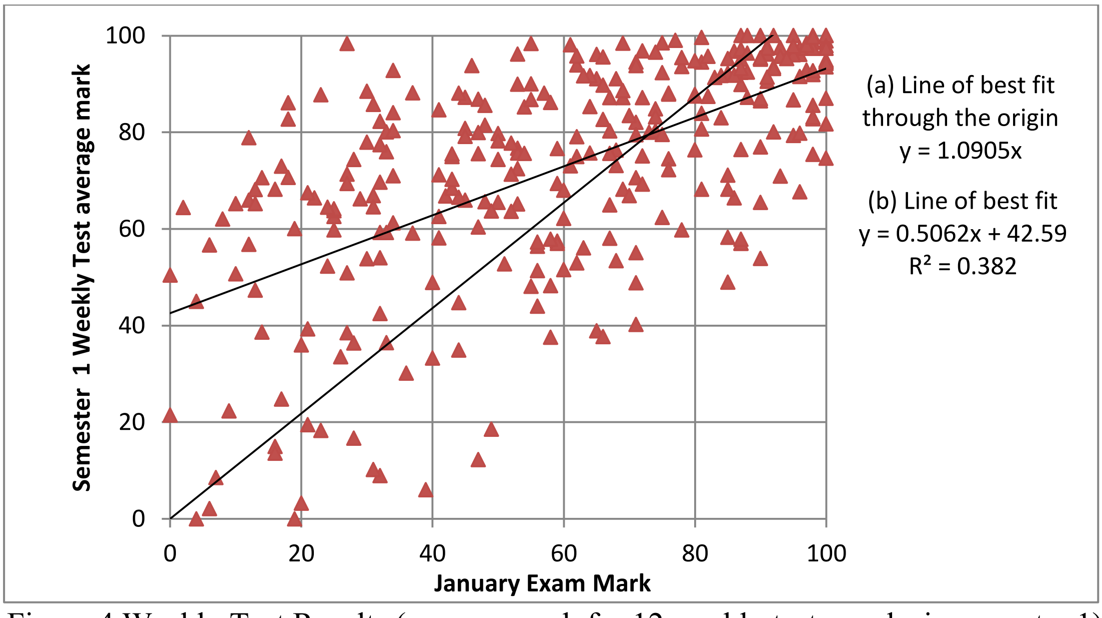


Figure 4.Weekly Test Results (average mark for 12 weekly tests marks in semester 1) versus January Examination results 2015-16.

Results are moving in the right direction in that the best fit trend line is moving closer to $y = x$ and the R^2 term, which measures closeness of fit to the best fit line (with 1 representing a perfect fit), has slightly increased from 0.3642 to 0.382. Nevertheless, our results indicate that on-line testing under uncontrolled conditions is not as good an indicator of future student performance as we had hoped. The January on-line examination, however, is a good indicator of success in the summer exam and hence overall success in the module. Figure 5 shows close correlation between the on-line January exam results and the written summer exam results for 2014-15.

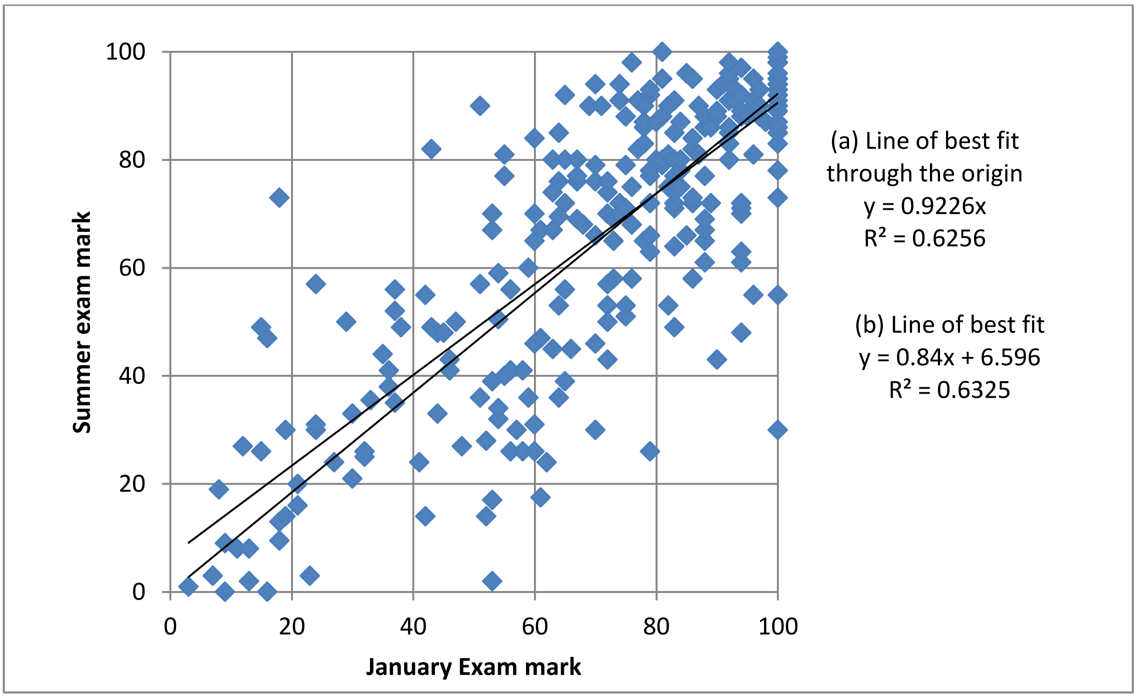


Figure 5. 2014-15 Examination Results showing the correlation between on-line January exam results and the written summer exam results.

We have therefore decided to use the January on-line exam results as an early indicator of student performance. In contrast, good engagement does not always mean module success.

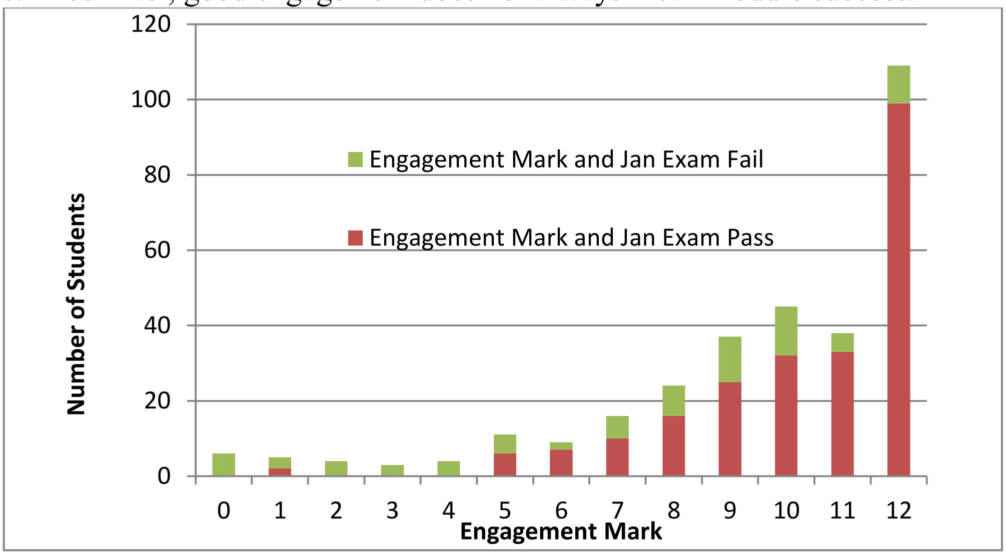


Figure 6: Jan Exam Performance vs Engagement. The engagement mark is only awarded if the student attains at least 40% in the weekly test before the engagement cut-off date for that test. The maximum engagement mark possible before the January Exam is 12.

Figure 6 shows that, as expected, those students that engage positively with the module have a good chance of passing the January exam and hence passing the module overall. However, there is a significant proportion of students who engage well (scoring an engagement mark of 8 or over out of a maximum of 12) who do not score well in the January exam.

On closer analysis, we are able to identify assessment performance with certain student cohorts. Figure 7 shows that those students who score well with the weekly tests but who do poorly in the January exam are predominately students with BTEC entry qualifications or Foundation level qualifications.

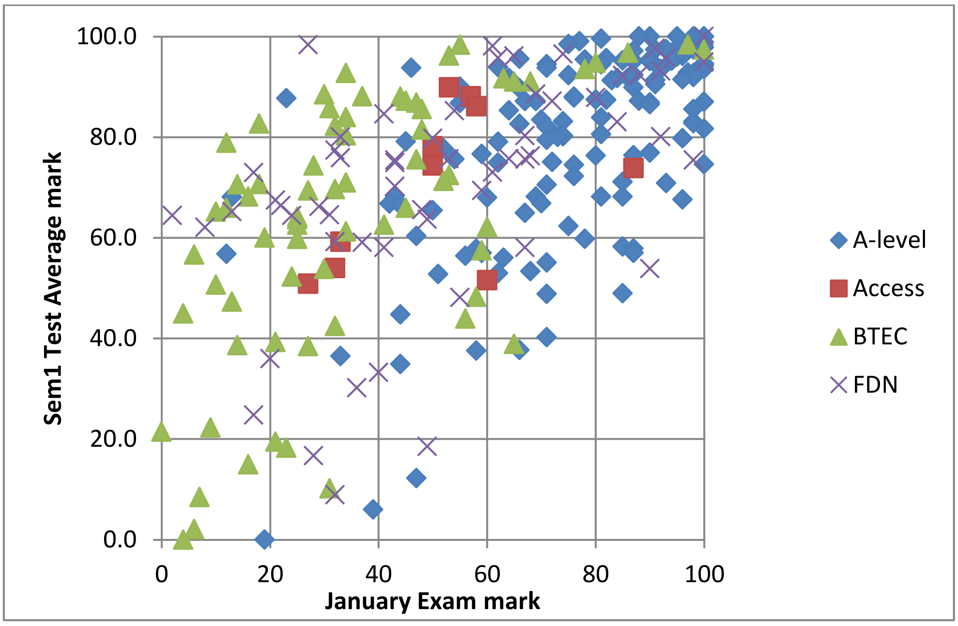


Figure 7 Weekly tests average score vs January exam 2015-16. Entry level breakdown

One main impact of this work so far is that all students with BTEC level entry qualifications will be given a two hour tutorial every week in 2016-17 as opposed to the normal one hour tutorial. In 2015-16 about 50% of the BTEC cohort received the two-hour tutorial. Extra support sessions are also available in the run-up to the examination period.

4. Conclusions

So far, we have drawn several conclusions from our work. Regular on-line testing under uncontrolled conditions is an important assessment feature of the module. It supports weaker students with their learning and ensures the stronger students remain engaged. However, on-line testing results under uncontrolled conditions are not a good indicator of student performance in the module overall. A controlled assessment, run on-line at the half-way point of the module run provides a good early indication of student progress and is sufficiently timely to identify those students who require extra support. More importantly perhaps, the on-line January exam provides a timely reminder to some students that they need to do some more work. Feedback data for the on-line January exam, which was available to students 3 days after the exam, shows that 241(out of 313) students viewed the feedback provided by DEWIS on their exam performance. (For standard written exams in the summer, feedback access is normally around 10% of the student cohort or less.) The substantial improvement in feedback viewing numbers is probably due to the fact that students can view the feedback while the exam is still fresh in their minds.

Analysis so far indicates that those students with BTEC level entry qualifications find Engineering Mathematics difficult. To overcome this, this group is being targeted with extra support including a 2-hour weekly tutorial session every week (instead of the normal one hour) and some support sessions on examination technique.

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Case Study: Comparison of Project-based, Creative Engineering Courses at Georgia Tech and Huazhong University of Science and Technology

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Abstract: Training engineering students to be innovative is a challenging, but rewarding educational goal. Improvements of methods to train for innovation and industrial practice have been the focus in engineering education. The course ME2110: Creative Decisions and Design in the School of Mechanical Engineering of Georgia Institute of Technology (Georgia Tech) focuses on teaching second-year students design methods that facilitate innovative thinking, as well as practical concerns. More than 500 students enrol in this course every year. In 2011, the School of Mechanical Science and Engineering at Huazhong University of Science and Technology (HUST) used ME2110 as a model and built the course MCDDT: Mechatronics Creative Decision and Design Tools. The MCDDT course is briefly described in the paper. Then， this paper comprehensively compares ME2110 at Georgia Tech and MCDDT at HUST in teaching, learning, and practice projects based on five years of experience. We analysis the similarities and differences in the syllabus, teaching modes in class and studio, practice project design, and studio hands-on tasks for students. To investigate learning outcomes, a survey was sent out to get feedback from both schools, we compare the attitude of students both at Georgia Tech and HUST to the course, presentation, hands-on tasks in studio and final competition. By performing this study to compare those engineering courses on creativity, some interesting results are concluded. These conclusions are very helpful for improving course teaching/learning quality.

Keywords: Engineering education, project-based learning, creative engineering course, hands-on task in studio, case study

1. Introduction

It has been realized for a long time that engineering students not only need to possess technical knowledge, but also need to be better educated in areas of creative decision, hands-on work, communication skills, teamwork and leadership [1]. Researchers indicated that the so-called “soft” skills, including creativity, communication, cooperation, leadership and organization, has become increasingly important for future engineers, where such “soft” skills include [2]-[4]. Active practice and innovation competence are a core component of engineering education, as well as key assessment factors of engineering education quality [5]-[6].To keep the step of world technology progress, innovation and creativity became a basic state strategy several years ago in China. Universities in China have been required to reform their educational philosophy to promote engineering student’s hands-on experiences and innovation ability [7]-[9]. But in engineering education, influenced by age-old traditional concept of “the theoretical knowledge prior to hands-on experiences” , there are still many engineering students prefer spending more time on theoretical knowledge studying to active practice and innovation competence training. They are usually regarded as "High-intelligence but low-creative" students.

Training engineering students to be innovative is a challenging, but rewarding educational goal. Improvements of methods to train for innovation and industrial practice have been the focus in engineering education. It is well known that hands-on experiences in engineering education are beneficial, as they increase both learning and enjoyment during coursework. The course ME2110: Creative Decisions and Design in the School of Mechanical Engineering of Georgia Institute of Technology (Georgia Tech) focuses on teaching second-year students design methods that facilitate innovative thinking, as well as practical concerns. More than 500 students enrol in this course every year. In 2011, the School of Mechanical Science and Engineering at Huazhong University of Science and Technology (HUST) used ME2110 as a model and built the course MCDDT: Mechatronics Creative Decision and Design Tools [10]. Based on the theory of project-based learning, this course is designed to provide students with both interesting and relevant hands-on experiences for a wide range of topics, including design processes, basic mechatronics concepts, technical communication, and working in a team environment. The course is set up for sophomores who have very little experience with engineering.

The MCDDT course is briefly described in the paper. Then， this paper comprehensively compares ME2110 at Georgia Tech and MCDDT at HUST in teaching, learning, and practice projects based on five years of experience. We analysis the similarities and differences in the syllabus, teaching modes in class and studio, practice project design, and studio hands-on tasks for students. To investigate learning outcomes, we survey the attitude of students both at Georgia Tech and HUST to the course, presentation, hands-on tasks in studio and final competition. By performing this study to compare those engineering courses on creativity, some interesting results are concluded. These conclusions are very helpful for improving course teaching/learning quality.

2. **Brief introduction to course** MCDDT

GATECH is well known for its achievements in engineering education. Creative decisions, innovation, teamwork, hands-on experiences and technical communications are emphasized in their curriculum. In the School of Mechanical Engineering at GATECH, these qualities are emphasized in the course Creative Decisions and Design (ME2110) [11]. ME2110 was developed for sophomores who usually do not yet have engineering experience. It is one of the most popular courses at GATECH; approximately 500 students select ME2110 every year. In addition to attending lectures, students are required to join studio sessions for hands-on exercises, as they must complete the team design project. At the end of the course, students present their machines in a competition.

With helps from GATECH faculties, a course, IMCDDT—Introductory Mechatronics Creative Decision and Design Tools—was created in 2011 at HUST. The course is conducted jointly by professors from HUST and GATECH. It is designed for sophomores who do not yet have any experiences with any engineering practice. In the course, students complete a design competition project after they learn the theoretical methods. By the time the students finish the theoretical knowledge learning, the hands-on jobs on the design competition project, their understanding in creative decision-making, collaboration, engineering design, and technical communication has been comprehensively trained to participate in the final competition. The process of learning in this course will provide students a good experience for their next two years of professional study.

The course is provided in each spring term for about 50 students. Since 2012, 5 classes of students, each having more than 50 students, attended the lectures, designed and built mechatronic devices and participated in the final competition. The course is now becoming a popular mechatronics course in the mechanical school of HUST. Pongxiang Yin, one student who enrolled in the course in 2012, wrote in his final report: “For a Chinese engineering student, it is a distinct opportunity to learn theoretical knowledge and to experience hands-on job in one course. The lectures, as well as the designed hands-on projects and the final competition, provide a platform for us to promote our competence of engineering creative decision, collaboration in team work, and practice. I like the course very much”.

3. Comparison of MCDDT and ME2110

As MCDDT is inspired by ME2110, there are some common ground between them. However, due to great differences between the east and the west in culture, education traditional concept as well as administration policies, there has to be also many differences between MCDDT and ME2110. In this section, we compares ME2110 and MCDDT in teaching, learning, practice projects, and achievements for both students and teachers based on five years of experience. We analysis the similarities and differences in the syllabus, teaching modes in class and studio, practice project design, and studio hands-on tasks for students.

3.1 Philosophy and goals

Originated from ME2110, MCDDT has almost the same philosophy and goals with ME2110. From the beginning of building MCDDT, the course’s philosophy is appointed to be “solving problems via team work, do-it-yourself activities, and learning from doing” . This is partly similar to ME2110’s philosophy: To learn by doing through team and individual projects and assignments.

The goals of MCCDT and ME2110 are list in the table 1.

Table 1 Comparison goals of MCDDT and ME2110

MCDDT	ME2110
(1) Cultivate students' practical ability, innovative thinking ability, decision-making ability, design ability, team work spirit, and competitive spirit.	(1) The techniques which allow an engineer to tackle new, unsolved, open-ended problems.
(2) Provide practical experience in hands-on building, design, and team work.	(2) To learn the fundamental procedures for solving engineering design problems.
(3) Train competence in innovation practice and creative thinking.	(3) Teach mechanical design techniques; teach oral and written technical communications skills. Develop basic machining and fabrication skills.
(4) Build an engineering education platform for learning mechatronics, creative decision making, and design tools.	(4) The essential details of analyzing, synthesizing, and implementing design solutions with flexibility, adaptability, and creativity. Introduce mechatronic concepts, pneumatic concepts.

(5) Build a new engineering education model by focusing on both practical training and theoretical teaching, project driven, hands-on production, and competition-based evaluation.	(5) Develop engineering project teamwork skills, allow students to produce a mechatronic device.
(6) Build a teaching group which comprises faculty from both HUST and GATECH. The group will become a model in innovative teaching and education reform of engineering education in the mechanical school of HUST.	
(7) Encourage faculty to keep pace with well-known universities through the world in both teaching ideology and teaching methodology.	

Goals (1)-(5) are similar in both courses, because these goals focus on learning for the engineering students. But goals (6)-(7) are only designed for course MCDDT, we hope professors in HUST can continuously update their teaching ideology and teaching methodology via MCDDT platform.

3.2 Teaching and learning

Teaching and learning are the key aspect to ensure the realization of goals. In this section, we compare the similarities and differences in syllabus, textbook and contents, and learning between MCDDT and ME2110.

- Syllabus

Course syllabus is the constitution of a course. It defines all aspect of the course. From the syllabus, you can know the course's objectives, attendance policy, assessment, etc. The syllabus of MCDDT and ME2110 are list in Table 2.

From Table 2 it can be found that the syllabuses of courses MCDDT and ME2110 are almost the same except the assessment section. In MCDDT's syllabus, the factors which students' final achievement(score) is determined are set with bigger intervals, which means students' final scores are somehow effected by professors subjective factors. But in ME2110 syllabus, every factor that could effect students' final scores are set with a small intervals. By this way, students' grades are unlikely impacted by subjective factors. The difference in assessment between MCDDT and ME2110 is probably caused by a culture difference: in east culture it is believed that the rule of man is important in management.

Table 2 comparison of syllabus

	MCDDT	ME2110
Course title	Mechatronics Creative Decisions and Design (international curriculum)	Creative Decisions and Design
Hours	lectures 16, practice training 24 hours	lectures 18, studio activities 30
students	sophomore	sophomore
Prerequisite	Mechanical Drawing, Physics	N/A

objective	● To develop ability to innovative decision ● To develop practical ability, design ability and teamwork ● Learning basic methods to solve engineering problems; ● Learning tools to analyze, synthesis, and accomplish solutions to engineering problems with flexible, practical, and creative means; ● Learning how to deal with new problems and challenges in engineering; ● Learning how to achieve an aim by teamwork	● To learn the fundamental procedures for solving engineering design problems; ● The essential details of analyzing, synthesizing, and implementing design solutions with flexibility, adaptability, and creativity; ● The techniques which allow an engineer to tackle new, unsolved, open-ended problems. ● To learn by doing through team and individual projects and assignments.
Textbook	William Singhose. Introductory Mechantronics Design Tools (Chinese-English Edition). Wuhan: Huazhong University of Science and Technology Press, 2012	W. Singhose, J. Donnell, Introductory Mechanical Design Tools, www.lulu.com/content/3365814 Also available as an iBook for the iPad (more interactive features than the hardcopy) https://itunes.apple.com/us/book/introductory-mechanical-design/id554549260?mt=11
Attendance policy	Students will be divided into groups of 3. Each group will complete all the assignments including the presentation and report, project manufacturing and competition, and project technical report and communication respectively.	Students will be working on teams to complete the projects for the course. Therefore, all students are required to attend all studio sessions.
Assessment	3 presentation and reports, 15% ×3 = 45% Practical training project manufacturing and competition, 40% Practical training technical report and communication, 15%	1) In-Lecture Quizzes 10% 2) Homework 15% 3) Class Participation 5% 4) Introductory Project 15% 5) Major project 55% Planning Report and Presentation (5%) Evaluation Report and Presentation (5%) Machine Performance (15%) Presentation to Judges (5%) Final Oral Presentation (10%) Final Report (15%) 6) Give at least one oral presentation P/F 7) Electronics, machining, and pneumatics training P/F

- Textbook and teaching

The course MCDDT use the textbook which is the Chinese-English version of ME2110 textbook. The textbook is written by Dr. William Singhose and Dr. Jeffrey Donnell.

The book provides a set of simple tools to aid novice designers. The tools address elementary design, teamwork, and technical communication. Chapter 1 provides a very brief introduction to design that discusses the phases and qualities of design. Chapter 2 provides methods for understanding a design problem. This, of course, focuses on understanding the customer needs. Chapter 3 introduces function trees and functional decomposition so that students can think clearly about the necessary functions and catalog them in a graphical format. Chapter 4 discusses specification sheets that list specific performance targets for a design. These design criteria will, of course, evolve and change throughout the design process as the problem and its possible solutions are better understood. Chapter 5 addresses conceptual design generation and evaluation. Chapter 6 presents some general safety guidelines. Techniques for detailed design of products are not covered in this book. Chapter 7 provides management and planning tools. Chapter 8 addresses team optimization, communication, and evaluation. Chapter 9 discusses the use of images in technical communication. Chapter 10 provides tools for generating technical reports. Chapter 11 describes the processes for documenting sources. Chapter 12 addresses details of presentations, with special attention to computer-based presentations. Appendices give sample technical reports and details on the mechanics of technical communication.

In course MCDDT the content of textbook is divided in four topics[10]:

(1) Tools for problem understanding

Tools for problem understanding include tools for understanding customer needs and decomposing product functions. In this part of the course, several tools are introduced to students: Problem Understanding Form, House of Quality, Function Tree, Function Block Diagram, and Solution Function Tables. These tools help students work effectively during the first stage of mechatronics design.

(2) Tools for conceptual design

Conceptual Design usually means specification development, concept generation, and safety considerations. In this part of the course, students learn to use tools such as the Specification Sheets, Morphological Charts, Concept Evaluation Matrixes, and safety consideration guidelines.

(3) Tools for project planning

The project planning tools taught in this part of the course are Planning Tree Diagram, Gantt Chart, Prioritization Matrix, Job Responsibility Matrix, and Peer Review Forms.

(4) Tools for technical communication

In this part of the course, students learn to communicate effectively with their team mates, managers, and customers. Methods for preparing images, writing reports, documenting sources, and editing technical presentations are taught to the students. Also, several communication tools via internet such as email, skype, QQ, and Wechat are reviewed for use as technical communication tools.

The course MCDDT is designed as Figure 1.

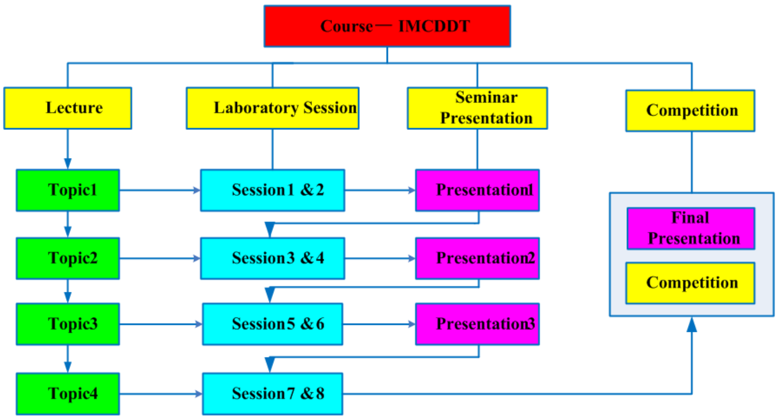


Figure 1 Design of Course MCDDT

Course ME2110 lectures all content of textbook in sequence. Besides classroom lectures, many studio lectures are designed for students to learn how to get start a project, how to use tools in studio to make their machines, how to design their machines, how to code, etc.

The studio lectures are very important for reaching the goal of the course. But in course MCDDT, there is no studio lectures designed in syllabus because the limitation of teaching hours. This inherent shortage of studio lectures results not only part of course goals cannot be realized but also increase difficulties for student to manufacture their machine.

- Learning

In both course MCDDT and ME2110, students are required to attend classroom lecture, studio session in teams. Every 3-4 students are randomly put in a no-leader team. Each student should complete his/her owner task and cooperate with his/her teammates to complete their team tasks. All classroom discussions/presentations, homework, and studio practices are attended in team. This arrangement forces students to learn how to collaborate with others and get used to teamwork. This is very important to their future careers. Figure 2 shows students work in team.

Figure 2 students work in team

With respect to the learning attitude, there are some differences between Chinese students and American students. Based on survey among students about the attitude to the course, presentation, hands-on tasks in studio and final competition, some phenomena are listed in Table 3. Those phenomena show the huge difference in motivations of study. For most Chinese students one of the most important goal is to find a good job and earn much money. In the east culture, it is a good moral that don't show personal talent in front of others. So it is a age-old tradition that either students or teachers in universities prefer class lectures to hands-on practices.

Table 3 Comparison of learning attitude between HUST and GATECH students

	HUST students	GATECH students
Classroom lecture	most Like, but because it is the first time to attend a foreign teacher's class, feel a little bit nervous.	Like but don't like some class policy
Presentation	Don't like, much of students think they need not show their talent before others, and they afraid of language problem	Like very much, every student want to show their talent before other, it is a good chance
Teamwork	Like, it is a good chance to learn how to collaborate with others	Like very much, it is a chance to learn leadship
Hands-on tasks in studio	Like, it is the first chance to do what they want to do and can learn some engineering knowledge	Like very much, they can put their idea into machine, also they can experience leader during hands-on work.
The final competition	Like and afraid, the last chance to show their talent but afraid of score if the machine failed to work	The most like thing, the biggest chance to show their talent their machine

3.3 Project and competition

In MCDDT and ME2110, projects and the final competition are very important parts of teaching. A mechatronics hands-on project is designed to achieve most of the course goals in both courses. Every student is assigned in a no-leader team. Every team member possesses his/her own sub-tasks, and he/she should collaborate with other members to integrate his/her tasks with the overall project tasks.

The design project is assigned to students at the begin of the course. Information related to complete the project is delivered during lectures. In the project period, students are required to design the mechatronic device using the methods presented in lectures. They also must construct the devices using the supply kit and facilities that are provided. Because it is a first building experience for many students, the construction task is a big challenge for them.

In course MCDDT, the theme of the competition is designed and inspired from a social event in the year of the course lectured. But in course ME2110, the theme of competition is based on fashion event, Greek mythology or science fiction, there is less relation to social events.

In both courses, students are required to document the process of the design and construction and to present design reviews to the class. Three presentations are given by each team during the project using this schedule.

To create a fair and interesting competition, while introducing the students to design in the face of conflicting requirements, a number of design constraints are placed upon the students' devices. For example, other than actuators provided in the supply kits, each team may buy no more than one actuator and spend no more than $100 (RMB150 in course MCDDT) to buy construction materials. Each team's device must small than designed dimensions. Students must also consider the aesthetics of their device because they will be evaluated by judges.

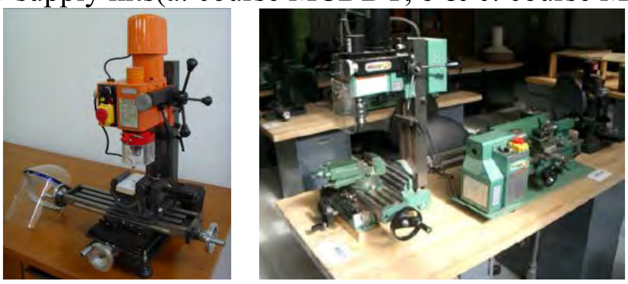
A supply kit is provided to each team. But there is a little of difference between two courses' supply kits. Figure 3 shows the supply kits respectively in course MCDDT and ME2110[1,12].

Part of tools in workshop provided to students is shown in Figure 4.

Figure 5 and 6 show students practice and final competition respectively.

a b c

Figure 3 supply kits(a: course MCDDT, b & c: course ME2110)



a b

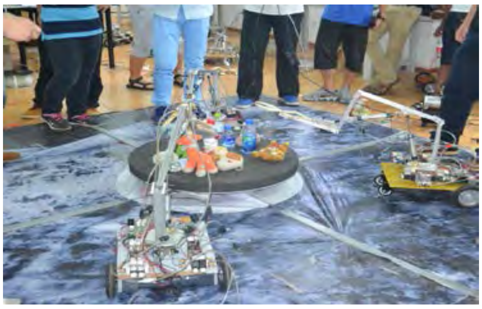
Figure 4 tools in workshop(a: HUST, b: GATECH)

a b

Figure 5 practice in studio(a: HUST, b: GATECH)

4. Conclusion

The course MCDDT and ME2110 are both designed to be interesting and to offer relevant hands-on experiences for a wide range of topics including design processes, basic mechatronics concepts, technical communication, and working in a team environment. The course is proven to be successful for sophomores who have no experience with mechatronics engineering knowledge. Students involved in course MCDDT and ME2110 leaned how to communicate and cooperate with their team members, which is essential for their future careers. Also, the teaching and learning practise shows that project-based teaching mode is an effective interaction methodology to organize lectures and studio sessions. Meanwhile, although the course MCDDT was built from ME2110, there are still many differences between both course. This may result from the differences of education philosophy, as well as culture differences between east and west.



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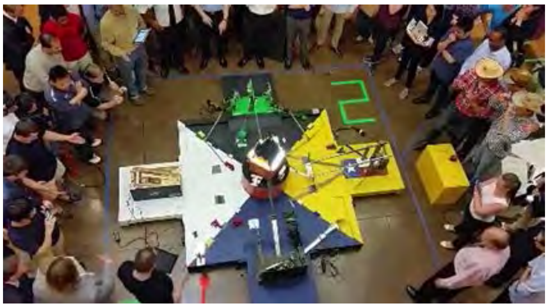

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Figure 6 final competition(a: HUST, b: GATECH)

Acknowledgements

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Expanding the scope of Biomedical Engineering curriculum

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Abstract: Engineering is frequently described as a problem solving discipline, such that it is not surprising to encounter trained engineers in endeavours in which they are not acknowledged experts – but which clearly require an analytical approach to tackle problems at hand. Biomedical Engineering may be viewed as a formal bridge between a highly analytical and predictable occupational outcomes with Newtonian boundaries, and biology: an open ended, Quantum Mechanical discipline with endless challenges to an enquiring mind. In the wake of epigenetics, universal factors have recently emerged as determinants of wellness and which provide additional challenges that need to be understood by everyone. This is of especial interest to Biomedical Engineers, who already have the advantage of a technical insight into Anatomy and Physiology.
This paper attempts to provide some pointers how aspects of this new knowledge maight be incorporated into the New Age Biomedical Engineering curriculum.

Keywords: engineering, education, biomedical, lifestyle, epigenetics

1. Introduction

Clinical medicine has always relied on tools provided by engineers (in their various guises), to provide their specialist input. This practice has not changed since the dawn of mankind, but what has drastically changed is the degree of sophistication of the process. This paper aims to provide a window into the recent changes in this proverbial "tool" in the wake of rapid developments in our understanding how our bodies respond to epigenetic factors, and suggests how this knowledge might be incorporated into a Biomedical Engineering curriculum. While this new knowledge is under continuous development, salient points have emerged that provide "road posts" for better understanding of pathogenesis –as well as help in avoiding the avoidable!
Current practice of medicine is substantially disease oriented. While disease will always be a component in clinical practice, scientific knowledge is emerging that Lifestyle has a cardinal impact on one's health. This is welcome news because escalating costs of clinical treatment, including the cost of essential infrastructure, point toward health maintenance and disease prevention as the ultimate option. Scaled down to an informed individual, it clearly provides a measure of self control over one's health, which also has a great potential impact on Government Public Health spending.

2. The conventional wisdom

Biomedical Engineering has grown currently to embrace a multitude of topics (e.g. Enderlie et al., 2003), such as listed below:

- Anatomy and physiology
- Bioelectricity
- Sensors
- Instrumentation
- Biosignal processing
- Physiological modelling

- Biomechanics
- Cardiovascular mechanics
- Biomaterials
- Tissue engineering
- Biotechnology
- Radiation imaging
- Ultrasound
- Nuclear magnetic resonance and magnetic imaging
- Biomedical optics and lasers
- Rehabilitation engineering
- Clinical engineering
- Morality and ethics

In order effectively to meet such challenges, it is also necessary to provide background information such that the practitioner may better comprehend his/her role and gauge the impact of their work. To this end introductory preliminaries (such as in Domach, 2003) are sometimes given in already overcrowded syllabus to cover non-engineering aspects such as,

- System principles of living organisms
- Biomolecular and cellular fundamentals and their engineering application

However, such an approach, widely practiced as it may be, does not look into the principles of pathogenesis and therefore does not provide an analytical overview, deemed essential by this author, for comprehensive understanding of a Biomedical Engineer to optimise his/her contribution to a given problem solution.

3. Didactic implications in the wake of full sequencing of the Human Genome

Since the full sequencing of the human genome in 2003, the expansion of knowledge into how the human body functions has been astronomical. For the purposes of this paper, it is imperative to highlight the emergence of epigenetics as the key to our survival. It provided the key into the apparent paradox (Lipton, 2015) in contravention of the conventional Biological Dogma: one gene begets one protein, as there were found only 21,000 human genes (approximately) and yet there are well in excess of 250,000 proteins in the human body (https://proteomics.cancer.gov). The answer was found by discovering that it is the external factors to the human genome that are the key to the seeming puzzle. This discovery provided a key to what happens to the human body as it interacts with its environment. This interaction of the human body with the environment is contained in an individual's Lifestyle. For the purposes of addressing the effect of Lifestyle on human body, it can be factored into the following elements,

- Nutrition
- Environment
- Disposition
- Chronic stress
- Locomotion

Each such factor is a major field of study and specialisation. Taken together, it may be labelled as the study of Lifestyle Medicine, an emerging field of study quickly overtaking former medical wisdom and providing everyone with an functional understanding needed for maintaining one's wellbeing our bodies have evolved to sustain. New fields of endeavour have emerged as the consequence, such as Nutrigenomics and Pharmacogenomics (amongst others) that focus on the effect of nutrients upon one's genome, as well as tailored dosage of a pharmaceutical that would maximise its beneficial effect given the specific patient's genome. Such sciences are a part of the Precision Medicine – tailor made to the individual patient. This was made possible through now generally affordable genome sequencing through one's specialist medical practitioner – involving just a few drops of saliva.

3. Lifestyle factors

In order to appreciate the overall effect of Lifestyle on our health, it is necessary to recognise that a person of today is biologically programmed to live in an environment some 250,000 years ago – a very short time span on the evolutionary time scale. Rapid changes in Lifestyle factors that have occurred since then, especially in the last few hundred years, exert their inevitable epigenetic effect on the human body. The human body thus exposed to Lifestyle changes has been unable fully to adapt, and if not deliberately mitigated, this effect will lead to undesirable health consequences (in susceptible individuals!).

3.1 Nutrition

The role of the nutrition is to provide elements essential for growth, maintenance and reproduction of species. To perform its role properly the ingested food has to contain nutrients essential for the performance of these functions. The science of Dietetics focuses on such details, as well as draws attention to pitfalls owing to denaturing of food through storage, processing, artificial preservatives, colouring and chemical contaminants in general, as well as gene modification. Lack of nutrients results in malnutrition, which is a precursor to major undesirable immunological consequences, apart from toxaemia due to accumulation of exogenous toxins. Cancer, a metabolic disease, is one major such an example.

3.2 Environmental Effects

It is not difficult to imagine thriving flora and fauna in the Stone Age era, unaffected by the contaminating by-products of contemporary living. Lack of chemical agents used in modern agriculture, no emissions from burning fossil fuels nor heavy metal contamination, no non-ionizing and ionizing radiation effects (accidental or deliberate), no smoke inhalation, no global warming, etc. provided an idyllic backdrop to the then otherwise harsh human life. However, this backdrop has drastically changed exerting a negative influence on flora and fauna of today. Its polluting effect is a major source of pathogenesis today.

3.3 Self Disposition

It is a medical fact that optimism is conducive to good health. Also, being positive in one's outlook has been recognised throughout the ages as the standard all should try to attain – exemplified by some notable religious practices, as thoughts bear upon the function of our endocrine glands and readily affect our health accordingly. Thus, some basics hitherto usually found in texts on good management practices for engineering managers, should find application more widely.

3.4 Chronic Psychological Stress Management

Stress has been essential for the species survival through preparing one's body for fight and flight. The mechanism is well understood as the HPA (hypothalamus, pituitary and adrenals) syndrome generating adrenaline for the purpose that activates body to respond. After the usually short such event, body functions turn to normal – as it escaped a mortal danger. However, chronic psychological stress (e.g. as in a work place) maintains this fight-and-flight state that adversely affects every organ in the body and is highly detrimental to wellbeing. It is essential to be aware of this and actively seek a resolution.

3.5 Locomotion

The physical exercise involved in hunting and food gathering of our ancestors is reduced to mostly sitting and some walking – a far cry from the Stone Age active food gathering "workouts": one's life depended on it. Lack of demand on our cardiovascular system leads to poorly nourished tissues and general physical decline with age as we mostly sit and perform mostly cerebral tasks. This lack of movement contributes to a rapid physical decline.

Having identified the principal factors that govern our wellbeing, the next task is to see them in the context of formal education that should be especially mandatory not only in Health Sciences but in (Biomedical) Engineering as well – which specifically aims to assist in our quality of life.

While Lifestyle Medicine takes into consideration genetic composition (or genome) of individual bodies, there is another factor that is of overriding importance: one's individual microgenome, the totality of genes in a colony of microbes living in symbiosis with us: externally and internally.

In summary, exposure to the adverse elements of Lifestyle leads to the loss of immunocompetence – exposing one's body to disease, as it has become defenceless.

4. Microbiome

The word "microbiome" is defined as the collection of microbes or microorganisms that inhabit an environment such as a human body, where it makes up communities of symbiotic, commensal and pathogenic bacteria (along with fungi and viruses). There are approximately 10 such microbes for every cell in a human body.

The foetal microbiome has its genesis – to a small extent in utero. It receives an overwhelming boost during normal delivery, which sets up the basis of its immune function. It reaches a mature status in 3 – 5 years and constitutes an adult microbial fingerprint that to a large extent governs how our body reacts, among other things, to pathogens. Because of its uniquely individualised nature, and overwhelming overreach on the functioning of all body organs, it must be addressed especially in any chronic health problem. The gut microbiome is mostly situated in the large colon where it constitutes a mass of about 2 kg. It is therefore important to consider the effect of nutrition on how it would impact on the microbiome, while bearing in mind its strong effect on the brain especially in terms of addictive cravings emanating from the also present harmful microbial cohabitants. Microbiome is effectively an external organ, without which the human body could not survive, because it contributes up to 80% of its immune function.

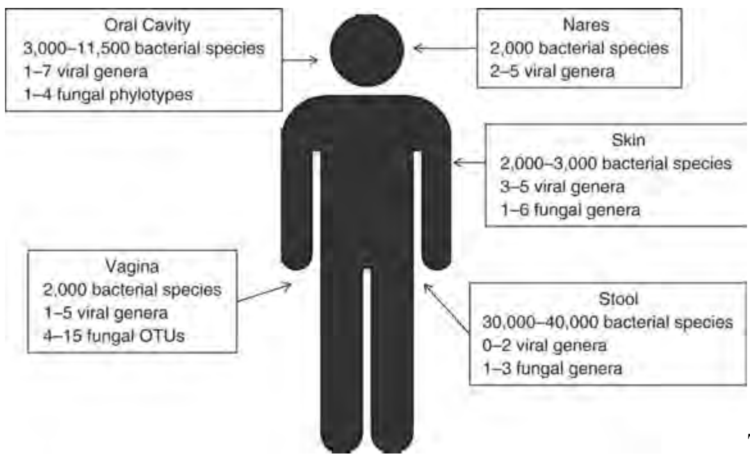

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Figure 1. Distribution of human microbiome
(B. Foxman & E.T. Martin, Am. J.Epidemiol, 2015; 182: 1-8)

5. Expanding the Biomedical Engineering curriculum

Given the above overview of the overriding importance of Lifestyle on one's health, and its cardinal effect on body's immune function, it ought to be formally incorporated into Biomedical Engineering curriculum (amongst other disciplines!) to provide not only the backdrop of the "tool" he/she is charged with developing – but ensure wellbeing of all involved! The questions remains how best to do it, and what to leave out?

Each element of Lifestyle taken in its entirety, is a discipline in its own right. Clearly, each cannot be presented in detail where only an appreciation of highlights relevant to Biomedical Engineering would suffice. It is an awareness only of the causative nature of each element that is of the essence here, and is seen only as a necessary adjunct to the major field of study. While there are not many informed potential presenters that have adequate overview of the subject relevant to Biomedical Engineers, each element of Lifestyle could have a separate expert in the field – present a lecture or two of highlight in his/her subject of expertise. This author had a similar experience in his past Biomedical Engineering lectures of inviting practicing medical clinicians, researchers, specialists as well as engineers from industry working on biomedical engineering devices – each present, with catching enthusiasm, his or her field of work. It was a huge success with students!

6. Conclusions

It is apparent that the way we live – our lifestyle, has an overreaching importance on our wellbeing. Lifestyle can be broken down into its constituting elements in order better to appreciate its overall significance:

- Nutrition – what constitutes the food we eat
- Environment – how pristine it is
- Disposition – are we positive or negative in our outlook?
- Chronic stress – how do we cope?
- Locomotion – do we move enough?

These elements can be presented formally in a classroom as a part of a Biomedical Engineering curriculum and an important adjunct to their professional and personal lives – as wellbeing of the community as a whole.

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Towards Developing an Awareness of the Cause of Health: Implications for Educators and Engineers

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Abstract: This paper suggests a simple explanation why disease may occur in spite of an in-built mechanism of body's self-maintenance. It thus hopes to empower individuals to take care of their own health, freeing medical practitioners to focus only on cases in need of professional help. The key to such an observation lies in Epigenetics which has come into focus following the completion of mapping of the Human Genome in 2003. It offers fruitful pointers into how our health is maintained and how help to resolve a chronic disease should it occur. It suggests how to override expression of undesirable genes inherited from parents, and in this way provide one with a measure of control over one's wellbeing. In addition, realisation of the unique microbial fingerprint that characterises biological individuality of its bearers helps to pave the way towards Precision Medicine that addresses the specifics for the most appropriate individualised therapy. This is slowly ushering the era of New Medicine with emphasis on effective disease prevention and treatment.

Keywords: Education, lifestyle, epigenetics, health, prevention

1. Introduction

We are invariably questioning the cause of ill health, while taking good health for granted. There are several reasons for that, but the principal one of concern here is that current practice of medicine is substantially disease oriented. However, this is changing, albeit slowly, with the advent of Precision Medicine and realisation of the cardinal impact of one's lifestyle on one's health. In addition, the escalating costs of clinical treatment, including the cost of essential infrastructure point toward health maintenance and disease prevention as the ultimate options.

The objective of this presentation is to bring to the attention of the audience the concept of wellness of a complex system, such as the human body, and its inherent self-maintenance – IF the conditions in which it finds itself allow it. The realisation of the principal role of the concerned individual in this scenario will hopefully inspire everyone to seek knowledge for maintaining their own wellness – and take appropriate action to that end through understanding the singular effect of Lifestyle.

2. Homeostasis

A good starting point would be the premise that everything has a cause, and the realisation that body has an inbuilt capacity to keep itself in good repair (through a dynamic health balance – homeostasis). However, this mechanism can be unwittingly impaired through lack of awareness that it exists and how it operates. For example, as a living creature, body needs nutrients to provide for energy and growth and produces waste in the process which it needs to get rid of, together with any accumulated foreign matter. If this is done well, body is in a natural state of wellness equilibrium or homeostasis. On the other hand – accumulated waste causes toxaemia, and disease inevitably follows, as it also would through chronic malnutrition.
Therefore, in the case of ill health we want to address – we have to go beyond symptoms and look for the cause, and in so doing use the failure of homeostasis to cope as the principal clue.

Fortunately there is a unique answer to this seemingly unfathomable puzzle:

Homeostasis was unable to cope because of the body's loss of immunocompetence – or in other words, our immune system failed to act in the manner for which it was designed because it was impaired.

The principal reason for this outcome is to be found in the manner of our **Lifestyle**:

- ***Our nutrition*** *– is it unadulterated, does it provide for all the body's needs?*
- ***The environment around us*** *– is it pristine and devoid of pollutants of all kinds?*
- ***Are we positive or negative*** *in our outlook?*
- ***How effectively do we cope with the chronic psychological stress?***
- ***How much do we move?***

A reasoned background for the above is that our biological make-up is built for the Stone Age environment in which polluting chemical toxins were absent from food and air, and psychological stresses were not chronic. In addition, moving in the perpetual search for food on foot was an accepted way of life! Some 250,000 years have elapsed since that time – which is inadequate for evolutionary adaptation to keep up with (e.g. Lipton, 2015). However, in the short term, epigenetic effects play a readily observable and major role on health outcomes for an individual, hence the importance of Lifestyle.

3. Chronic inflammation

Accumulation of the metabolic waste, chemical residues from ingested foods (including heavy metals), ingestion of drugs, malnutrition, psychological stress, environmental pollution – all give rise to compromised body's immune function, and hence chronic oxidative stress resulting in chronic inflammation. This mechanism ultimately leads to the expression of a disease as opportunistic bacteria proliferate and in this way exert a negative impact on body's health status. Or expressed more succinctly, owing to the impaired homeostasis, chronic inflammation sets in and grows (if unchecked) until ultimately disease develops.

3.1 Oxidative stress

Presence of excessive numbers of free radical originating from endogenous as well as exogenous sources in the body causes physical trauma (inflammation) in the affected part of the body, and if chronic, is a precursor of many diseases, Fig. 1.

The simple recipe how to avoid all these undesirable consequences is to mitigate or avoid chronic inflammation by simply consuming staple food of our ancestors – by avoiding to a large measure anything artificial (e.g. GMO), contaminated or processed. In addition, exposing our bodies to pollution free environment (this includes amalgam fillings !), minimising contact with chemicals, avoiding smoke, EMR, etc. would be close to the environments our Stone Age ancestors lived in. Also being positive in every way would ensure a positive response of our endocrine system to such assaults on our bodies.

Negative disposition as well as chronic psychological stress are also highly toxic and should be addressed through various modalities of relaxation.

The excess of free radicals giving rise to oxidative stress is caused by the lack of antioxidants, i.e., negative charge. Antioxidants are mostly found in fresh fruit and vegetables. However, another source is the surface of the Earth (the proverbial storehouse of electrons) with which contemporary humans have largely lost intimate contact by not walking barefoot on it any more (in cities, anyway!). Wearing insulating soles made from rubber or plastics, lets positive charge (i.e. free radicals) predominate causing oxidative damage.

Figure 1. Diseases related to oxidative stress

4. Chronic psychological (emotional) stress

Human body has evolved to respond to sudden physical danger by the fight-or-flight mechanism characterised by instinctive response to flee the danger or fight it – to survive. Physiologically it is characterised by the outflow of blood from viscera into arms and legs, and activation of the instinctive part of the brain to respond to the life-threatening situation rather than thinking about it and, in the meantime be overwhelmed by it. This physical effect was activated by prompt response to a signal from the pituitary gland which received the message from the hypothalamus in the brain. The secretion of adrenaline into the bloodstream from the adrenal glands was the final step in the process. The whole process is labelled as the "HPA response to the momentary stress", a well established process in the body's survival mechanism. After the successful escape from the danger, the body returns to the normal, stress-free state. However, if stress persists for longer time, it becomes detrimental to the whole body – and impairs its "proper" (i.e. "stress-free") function. Consequences are devastating as may be seen in Fig. 2.

Absence of the normal pool of blood in the viscera has a notable effect on body's immune function designed to principally cope to danger to the body from within – the unfriendly microbes. Cognitive function is also affected, with individuals "reacting" to the world around them rather than being "proactive". This may be evident in the newborn whose mothers were subjected to chronic stress while pregnant.

There are many ways to mitigate the effects of psychological stress – by consciously “disconnecting” mind from the body. The Harvard School of Medicine (Harvard, 2015) provided the following advisory:

- **Stay positive**. Laughter has been found to lower levels of stress hormones, reduce inflammation in the arteries, and increase "good" HDL cholesterol.
- **Meditate**. This practice of inward-focused thought and deep breathing has been shown to reduce heart disease risk factors such as high blood pressure. Meditation's close relatives, yoga and prayer, can also relax the mind and body.
- **Exercise**. Every time you are physically active, whether you take a walk or play tennis, your body releases mood-boosting chemicals called endorphins. Exercising not only melts away stress, it also protects against heart disease by lowering your blood pressure, strengthening your heart muscle, and helping you maintain a healthy weight.
- **Unplug**. It's impossible to escape stress when it follows you everywhere. Cut the cord. Avoid emails and TV news. Take time each day — even if it's for just 10 or 15 minutes — to escape from the world,
- **Find ways to take the edge off your stress**. Simple things, like a warm bath, listening to music, or spending time on a favorite hobby, can give you a much-needed break from the stressors in your life.

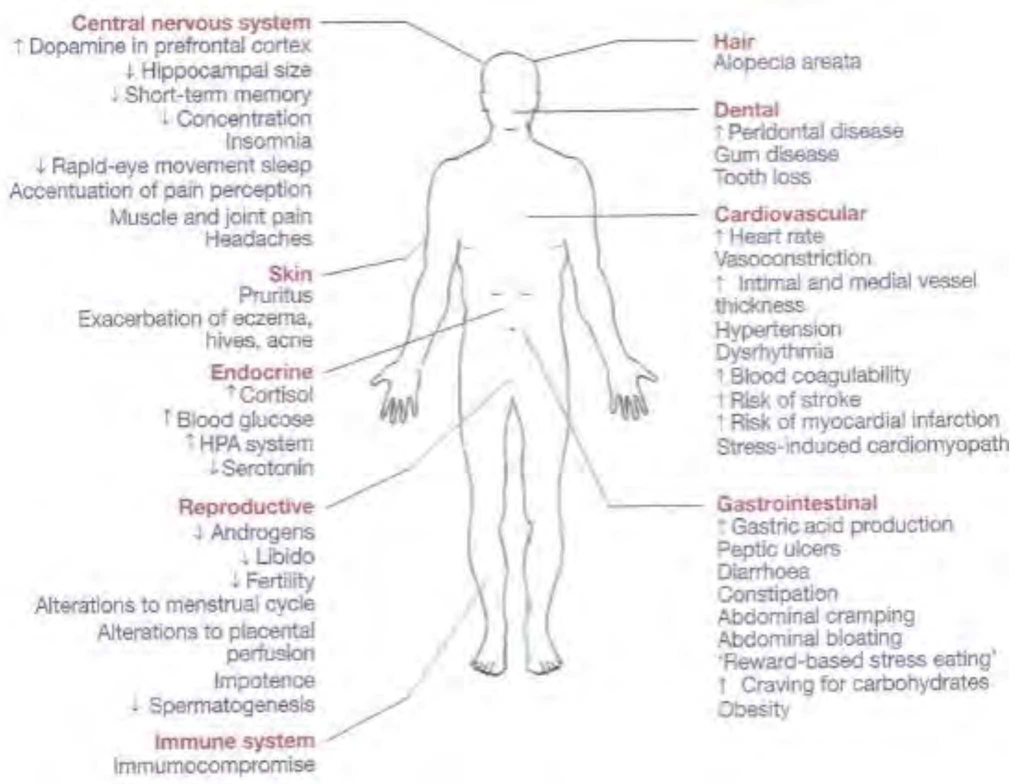

Figure 2. The effect of chronic psychological stress on human body.
(Bullock & Hales, 2013)

4. The role of Human Microbiome

The word “microbiome” is defined as the collection of microbes or microorganisms that inhabit an environment such as human body, where it makes up communities of symbiotic, commensal and pathogenic bacteria (along with fungi and viruses). There are approximately 10 such bacterial microbes, and 100 times more viral particles, for every cell in a human body. Fig. 3 shows their approximate distribution on and within the body. Microbiota have been associated with obesity, the metabolic syndrome and even autism. They have a vital role to play in the body's immune function, digestion of food, resist invasion by pathogens, and synthesize essential vitamins (Foxman & Martin, 2015). Awareness of their existence within us and their overwhelming importance in terms of our immune function, mandates we take a good care of them so that they may do the same to us in return!

The microbiome has its genesis – to a small extent in utero. Foetus receives an overwhelming exposure to micobes during normal birth delivery, which readily sets up the basis of its immune function. It reaches a mature status in 3 – 5 years and constitutes an adult microbial fingerprint that to a large extent governs how our body reacts, among other things, to pathogens. Because of its uniquely individualised nature, and overwhelming overreach on the functioning of all body organs, it must be addressed especially in any chronic health problem. The gut microbiome is mostly situated in the large colon where it constitutes a mass of about 2 kg in an adult. It is therefore important to consider the effect of nutrition on how it would impact on the microbiome as well as the effect of environment to which it is particularly sensitive (more than the human genome). Microbiome is effectively an external organ, without which the human body could not survive, because it contributes up to 80% of its immune function. Liberal use of antibiotics has a devastating and long lasting effect on microbiome, and their application should be limited.

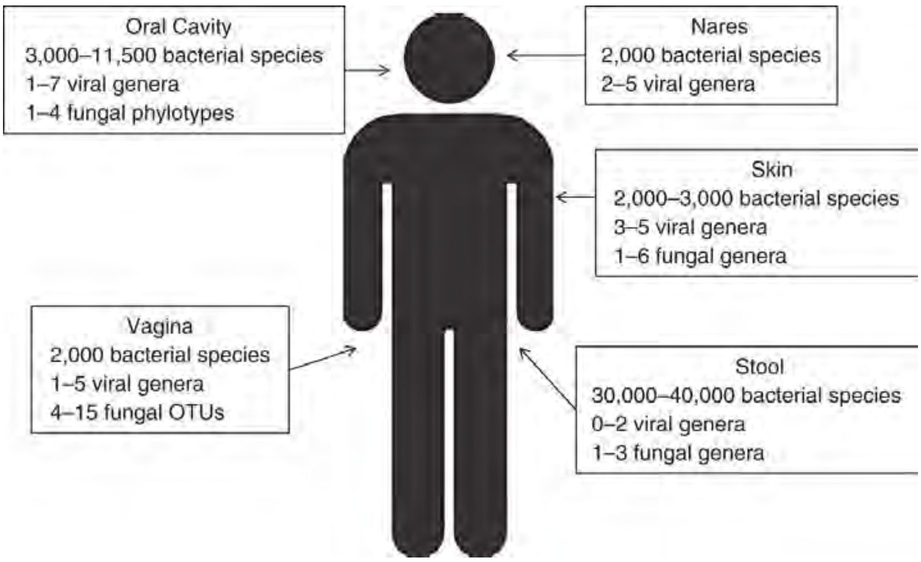

Figure 3. Distribution of human microbiome
(Foxman & Martin, 2015)

Human genome is miniscule when compared to the diversity of human microbiome Fig. 4, which is indicative of the major effect it has on the human body. The general effect of microbiome may also be thought of as a shield providing a resistance to potentially invading pathogens as well as playing a role in metabolism of toxins or in general, a benign filter between the body and environment.

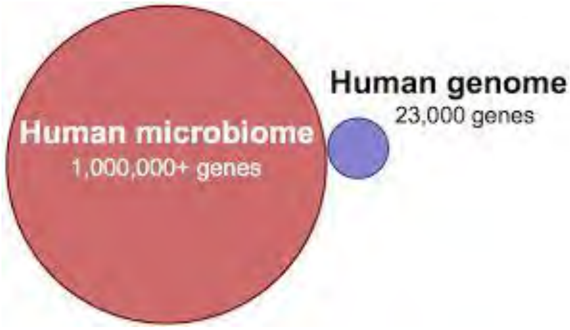

Figure 4. Graphic comparison of the size of the Human Microbiome and Human Genome

6. Lifestyle factors

The elements of Lifestyle are readily identified as the sustainers of life and are described below.

6.1 Nutrition

The role of the nutrition is to provide elements essential for growth, maintenance and reproduction of species. To perform its role properly the ingested food has to contain nutrients essential for the performance of these functions. The science of Dietetics focuses on such details, as well as draws attention to pitfalls owing to denaturing of food through storage, processing, artificial preservatives, colouring and chemical contaminants in general, as well as gene modification. Lack of nutrients results in malnutrition, which is a precursor to major undesirable immunological consequences, apart from toxaemia due to accumulation of exogenous toxins. Cancer, a metabolic disease, is one major such an example.

6.2 Environmental Effects

It is not difficult to imagine thriving flora and fauna in the Stone Age era, unaffected by the contaminating by-products of contemporary living. Lack of chemical agents used in modern agriculture, no emissions from burning fossil fuels nor heavy metal contamination, no non-ionizing and ionizing radiation effects (accidental or deliberate), no smoke inhalation, no global warming, etc. provided an idyllic backdrop to the then otherwise harsh human life. However, this backdrop has drastically changed exerting a negative influence on flora and fauna of today. Its polluting effect is a major source of pathogenesis today.

6.3 Self Disposition

It is a medical fact that optimism is conducive to good health. Also, being positive in one's outlook has been recognised throughout the ages as the standard all should try to attain – exemplified by some notable religious practices, as thoughts bear upon the function of our endocrine glands and readily affect our health accordingly. Thus, some basics hitherto usually found in texts on good management practices for engineering managers, should find application more widely.

6.4 Chronic Psychological Stress Management

Stress has been essential for the species survival through preparing one's body for fight and flight. The mechanism is well understood as the HPA (hypothalamus, pituitary and adrenals) syndrome generating adrenaline for the purpose that activates body to respond. After the usually short such event, body functions turn to normal – as it escaped the mortal danger. However, chronic psychological stress (e.g. as in a work place) maintains this fight-and-flight state that adversely affects every organ in the body and is highly detrimental to wellbeing. It is essential to be aware of this and actively seek a resolution.

6.5 Locomotion

The physical exercise involved in hunting and food gathering of our ancestors is reduced to mostly sitting and some walking – a far cry from the Stone Age active food gathering "workouts": one's life depended on it. Lack of demand on our cardiovascular system leads to poorly nourished tissues and general physical decline with age as we mostly sit and perform mostly cerebral tasks. This lack of movement contributes to a rapid physical decline. It is therefore suggested, that our Lifestyle be attuned to our biological make up by harking back to the hunter-gatherer era and consume genuine (unprocessed) unadulterated, non-GMO produce. In addition while at all times remaining positive in our outlook, we should seek pristine environment in which to live and work, unplug occasionally and minimise sitting down!

Having identified the principal factors that govern our wellbeing, the next task is to see them in the context of education at all levels.

In summary, exposure to the adverse elements of Lifestyle leads to the loss of immunocompetence – exposing one's body to disease, as it has become defenceless.

6. Implications for Academics and Professionals

Each occupation carries a specific health risk in terms of compromising some if not all aspects of Lifestyle. The important feature applicable to all adverse aspects of Lifestyle is the duration of its exposure and an individual's susceptibility. Clearly, it is highly beneficial to minimize exposure to such adverse aspects of Lifestyle and deliberately undertake appropriate measures to reduce if not erase their consequences. Academics and Professionals make up a special group of workers which is exposed to a great amount of psychological stress, particularly engendered by demanding responsibilities, tight deadlines and the amount of work required to perform their function. A quick reference to Fig. 2 reveals the inevitable consequences that would follow overexposure to such stresses without adequate recuperating interval. Focusing on all aspects of the Harvard health advisory on p.4 of this paper would be an excellent start to let the body recuperate from the negative influence of the psychological stressors. While it is professionally mandatory to complete all the required tasks, individuals have to ensure that their self maintenance is not impaired by occasionally "unplugging".

7. Conclusions

Lifestyle has an overarching effect on health – it is THE cause of our wellbeing given our genome and microgenome. It provides everyone with a control over his/her health by simply following the principles of Lifestyle we are biologically built to thrive in.
In summary, the principal elements of Lifestyle are:

- Nutrition – what constitutes the food we eat?
- Environment – how pristine is it?
- Disposition – are we positive or negative in our outlook?
- Chronic stress – how do we cope?
- Locomotion – do we move enough?

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Use of Flipped Classroom Approach in Project Based Learning: Student Perspective

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Abstract:

Flipped classroom (FC) is an active learning approach that effectively harnesses students' creativity. In this approach, learning materials are provided to students prior to face-to-face interactions and the class sessions are used for discussions and to answer any questions the students may have. Lecturers and tutors take on the role of facilitators and the students take the responsibility for their own learning both inside and outside the classroom.

Project based learning (PBL) uses real world projects to prepare students confidently face the challenges when they graduate and enter the workforce. The method is learner centred and relies heavily on peer support. It uses multitude of learning strategies, ultimately leading to the team chosen pathway to complete the project. PBL facilitates the development of creative and independent thinkers and learners. The result is motivated and engaged students culminating in better learning outcomes.

At Western Sydney University (WSU), FC strategy has been implemented in a core civil engineering subject (unit) that uses the PBL method. This paper presents the students perceptions on the effectiveness of the strategies used in the development and implementation of the hybrid approach. Effectiveness is deduced from the qualitative analysis of student journals, in-semester feedback and student performance. Emerging themes were used as surrogates of effectiveness.

Keywords: flipped classroom, project based learning, learning management system

1. Background

Engineering at Western Sydney University (WSU) currently uses traditional learning and teaching (L&T) strategies. Typically, students are exposed to theories via lectures, usually in tiered lecture theatres in-front-of a large cohort of students. One-on-one interactions with students occur in follow-up tutorial sessions, held in tutorial rooms, usually comprising of 25-30 students. These are also the sessions where students' are engaged in problem solving and where most of their queries are answered. Laboratory sessions, if and when deemed necessary, are held to reinforce the principles covered in lecture sessions. The lecture and tutorial sessions are complemented by relevant postings on vUWS, the Learning Management System (LMS) used at WSU. Typically, all lectures are recorded and posted on vUWS - to help students to catch-up (for those who missed the lecture sessions) or revise the theories covered in lecture sessions.

A hybrid system that uses flipped classroom strategy and project based learning was developed and implemented in a core engineering subject at WSU. This paper presents the student perceptions on the effectiveness of the strategies used in the development and implementation of the hybrid approach. Effectiveness is deduced from the qualitative analysis of student responses and student journals.

2. Learning and Teaching approaches

The rapid advancement in information technology is making it simpler and relatively inexpensive to develop interactive L&T material (Bishop & Verleger, 2013). This advancement in technology, along with the recognition that students retain only a small proportion of information presented in lecture sessions (Al-Zahrani, 2015), have given impetus to alternate strategies for development and delivery of L&T material. One such strategy is the 'flipped classroom' (FC) approach, where students take ownership of their own learning outside the classroom and the class time is used for discussions. This approach has resulted in improved student engagement and learning (Kim, Kim, Khera, & Getman, 2014; Mason, Shuman, & Cook, 2013). Another widely used strategy is the use of 'project based learning' (PBL) where students work collaboratively in teams to solve authentic real-world projects. In this approach, students take their own pathway for completing the project (Robinson, 2012). This results in motivated and engaged students culminating in better learning outcomes.

2.1. Flipped Classroom

Flipped classroom (FC) is an active learning approach that effectively harnesses students' creativity (Mason et al., 2013; O'Flaherty & Phillips, 2015). In this approach, learning materials are provided to students prior to face-to-face interactions and the class sessions are used for discussions and to answer any questions the students may have. This method allows them to spend more time helping students to solve problems in class, leaving students to learn relevant material at their own pace outside the classroom (Velegol, 2015). Lecturers and tutors take on the role of facilitators and the students take the responsibility for their own learning both inside and outside the classroom. The process takes a learner through the whole spectrum of learning taxonomy – from 'remember' → 'understand' → 'apply' → 'analyse' → 'evaluate' → 'create' (Krathwohl, 2002). The rapid advancement in information technology has made this approach very popular in recent years (O'Flaherty & Phillips, 2015).

2.2. Project Based Learning

Project based learning (PBL) uses authentic real world problems to prepare students confidently face the challenges when they graduate and enter the workforce. The method is learner centred and relies heavily on peer support (Bell, 2010; Robinson, 2012; Savery, 2015; Thomas, 2000). Depending on the team dynamics, PBL uses multitude of learning strategies to solve the project on hand. Designed and implemented properly, PBL facilitates the development of creative, independent thinkers and learners who take responsibility for their own learning (Bell, 2010). The result is motivated and engaged students culminating in better learning outcomes.

The learning outcomes will be meaningful when the projects mimic real world situations. Another advantage of authentic real world problems is better student engagement when they see relevance of the projects they're trying to solve (Robinson, 2012). The accrediting body of engineering programs in Australia, Engineers Australia, has recognised this requirement through embedding of one of the core competencies required of engineering graduates; i.e. a graduate's ability to successfully apply 'established engineering methods' to solve 'complex engineering problems' (Engineers-Australia, 2013, p. 2). Formulation of authentic real world problems as projects, in engineering curriculum, can be achieved through partnership with industry. Success of one such venture is described in Bhat, Sujatha, Mohan, and Prakash (2015).

2.3. Hybrid Approach

While PBL and FC, on their own, have been proven to be effective, the research team is not aware of any attempt to blend the two approaches in L&T. The project this manuscript is based on is an attempt to fill this void through development and implementation of a hybrid approach in a core civil engineering subject at WSU. With the continued development in technology and the current approaches to design and implementation of collaborate learning spaces (CLSs), it is anticipated that the hybrid approach will result in better learning outcomes.

3. Implementation in a core Civil engineering subject

Surface water hydrology is a core undergraduate civil engineering subject (unit). It is a level 4 unit where students solve real-world engineering projects in teams (3-4 members per team). The subject has been designed as a PBL unit and the material required to complete the project are provided in smaller bites (power point files and a series of pre-recorded or sourced video files posted on vUWS) as in the FC format.

Regular lectures and tutorials have been replaced with full day workshops where the lecturer takes on the role of a facilitator. The students come to the workshop sessions after completing pre-class activities (reviewing the power points and the videos posted on vUWS). The class time is used to work in teams, to solve their projects. The time is also used as opportunities to ask questions to the facilitator. In addition, these sessions are also used to provide guidance and additional 'just-in-time' L&T material. The team members follow up 'in-class' work by working outside the class ('post-class' tasks) in teams. Individual and team portfolios are then posted on vUWS, including a summary on reflections on their learning.

4. Data Collection, Analysis and Results

A total of 95 students were enrolled in surface water hydrology in Autumn 2016. These students were assigned into three workshop sessions. The number of students in each workshop session varied – with 23, 31 and 41 students in the three workshop sessions. A total of 26 project teams were formed. Each team were assigned a project during the first workshop session. Team formations also occurred during this session.

4.1. Data Collection

Students enrolled in the unit were sent e-mails at the end of the second workshop asking them to provide feedback on how the unit was progressing. The e-mails sought open-ended responses on the effectiveness of the L&T strategies implemented in this unit. Specifically, the students were asked to provide their experiences on whether their teams were working effectively or not. The students were also asked to list 'best' and 'need improvements' aspects of the unit. In addition, they were encouraged to suggest strategies to help them achieve better learning outcomes. A total of 15 students responded to the e-mail request. In addition to the e-mail responses, postings of 25 journals were extracted from the learning management system at Western Sydney University. The 25 journals were chosen at random.

Both the e-mail responses and journals were de-identified before analysis.

4.2. Data Analysis

The 25 Journals were extracted and de-identified by Mr Noshir Bulsara, Blended Learning Designer at the School of Computing, Engineering and mathematics. All responses were assigned one of the five categories – (a) team dynamics, (b) flipped classroom, (c) project based learning, (d) learning space and (e) student initiative. All the responses related to working in a team environment were assigned 'team dynamics' category. Similarly responses related to the real world project and class preparation were assigned 'project based learning' and 'flipped classroom' categories. As the unit was delivered as workshops in a technology enhanced collaborative learning space, there were a large number of responses related to the room. All responses related to the teaching space were assigned 'learning space' category. The flipped classroom approach and the workshop style also meant students needed to be on their toes all the time. All responses related to students taking responsibility for their own learning were assigned 'student initiative' category.

All 25 journals were reviewed and the number of responses in each category was listed. The responses were listed as positive and negative; positive responses indicating the positive experience the students had in that category and negative representing the negative response. The responses were then standardised and the results are shown in Fig. 1.

4.3. Preliminary Results

It is evident from the student responses, shown in Fig. 1, that the students had an overwhelmingly positive response in the unit. There was a mixed response (50-50) to the learning space. Majority of negative responses related to wi-fi connectivity in the room. It is interesting to see perfect positive response in the flipped classroom category. Similarly, the response in the project based learning category was very good, with close to 95% of positive responses. In addition, the students seem to work well as teams, with close to 91% of students providing positive response in this category.

The response on student initiative category was not as good, though; with just over three quarters of responses being positive. There seems to be a strong correlation between these responses and the student performance thus far (project report yet to be marked). As can be seen from Fig. 2, a quarter of the students are in the verge of failing this unit (lower quartile of 48 mark). The higher proportion of positive responses seen in Fig. 1 are also supported by the high average mark (61.3%) of the cohort and the higher proportion of students (more than 25% of cohort) achieving Distinction and High-Distinction range of marks.

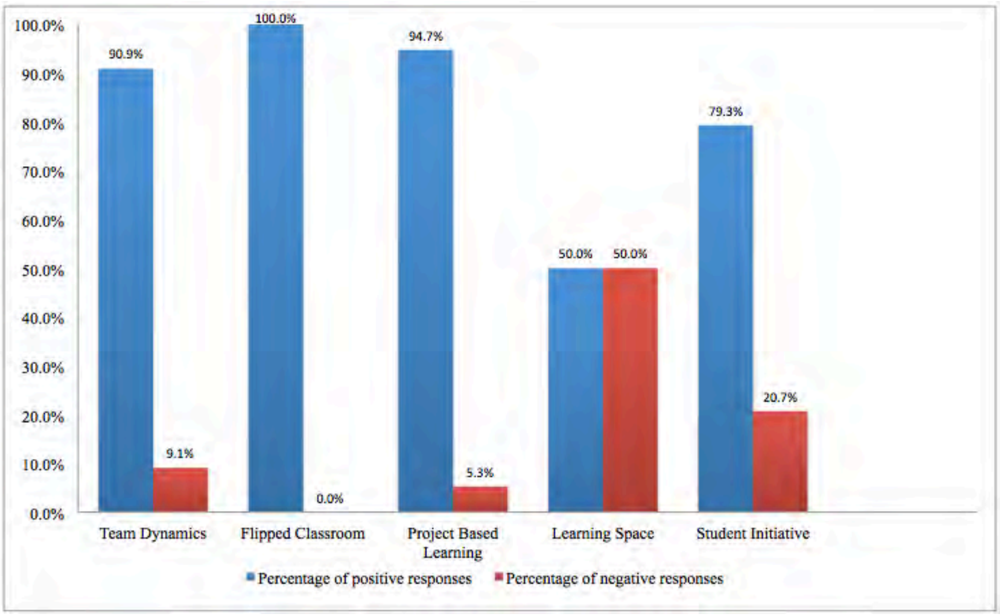

Figure 1. Student responses (collated from 25 randomly selected journal entries)

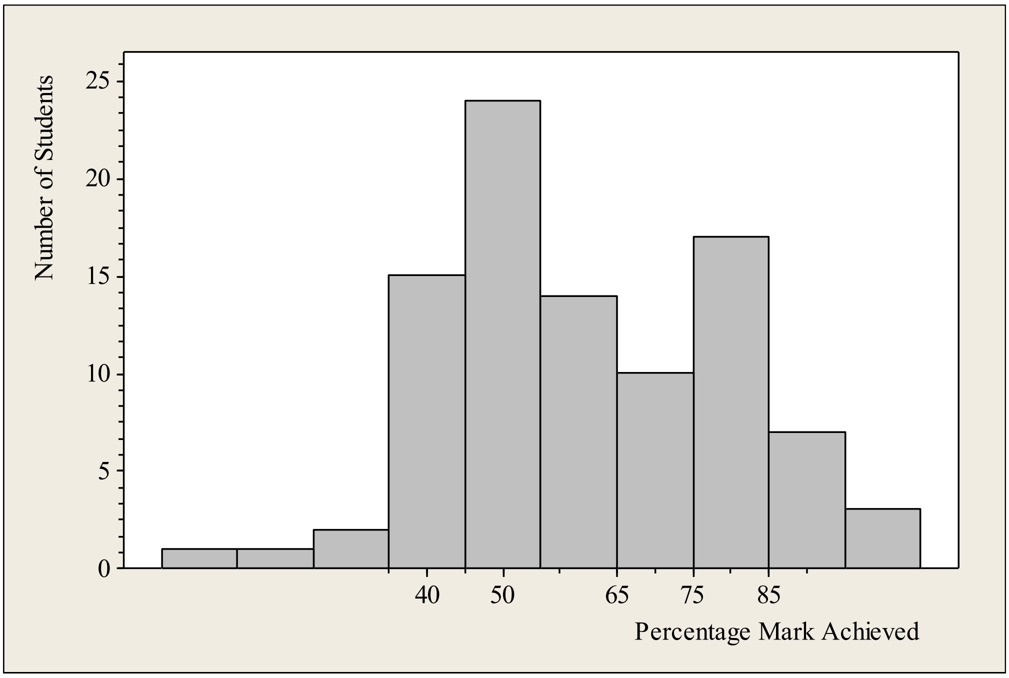

Figure 2. Mark Distribution

5. Discussions

The hybrid approach has been well received by the students as they found the content and its delivery method interesting and engaging. Improved engagement has also been attributed to the design of the learning space however feedback also revealed that many of the students had issues with the technology in the space. These issues can be remedied and if done so could prove to have a better outlook on this learning and teaching approach.

As a result of the PBL format a majority of the students enjoyed and found the unit content to be applicable to real world situations. A small proportion of students did not adapt well to the change, needing more guidance for tasks at hand. Most students, however, took the responsibility for their own learning and took initiatives in retrieving information and bringing queries to the facilitator outside of the workshop sessions.

Comments on the videos prescribed to watch before workshops showed that the students found the videos to be a good medium to deliver instructional information on content. Contents in the videos helped the students learn the unit material, discover possible issues and to then be able to ask meaningful questions in the workshop. Overall there was no negative feedback directly about the videos. However, some responses suggested including supplementary tutorial styled short sessions where example problems could be presented. Suggestions also included for additional instructions and additional explanations on some of the pre-workshop videos.

6. Conclusions

The hybrid approach was popular with students and helped achieve the desired learning outcomes. The students were found to be more engaging when compared with the traditional lecture/tutorial/laboratory style delivery. The use of projects enabled the students to see practicality of what they were doing and how these could be implemented in the real world situation. This realisation added curiosity and excitement among the team members. The study reinforced the findings of previous researchers that project based learning approach motivate and engage students to find their own pathway to complete assigned project. The flipped classroom strategy helped teams when they were trying to navigate through the tortuous pathway. The workshop sessions acted as the comfort zones. These sessions also provided additional avenues to find answers to the questions the students were struggling during their journey.

7. Acknowledgements

The authors acknowledge Mr Noshir Bulsara, Blended Learning Designer at the School of Computing, Engineering & Mathematics, who extracted the journal entries from the learning management system and de-identified the data. The authors also acknowledge the feedback the students of the unit provided throughout the semester.

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Preservation and Succession of Traditional Skills and Techniques of Woodwork using Digital Tools

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Abstract: In Japan, although many local special traditional skills exist in many places, it became difficult to preserve and succeed, because of aging of these masters and shortage of successors in recent years. Superior traditional skills and techniques cannot be continued without succession in various fields. So, it is required that the traditional skills and techniques specialized for an individual will be preserved and succeeded by changing into objectivity data and reproducible. In this study, a wooden ship is used as research object and data is reconstructed. In addition to multimedia such as movies, pictures, sounds and documents, possibility of the new preservation and Succession method using 3D-CAD is proposed here.

In addition, optical motion capture system is used to preserve and to succeed skilled motion. To analyse human's motion, it is recorded by means of optical motion capture system. We can know the position of joints by using captured data and compare the motion of the apprentice with the master. The plane motion of carpenter master was captured in this study. Beginner's motion and skilled motion are analysed and compared. As a result, it was clarified that the master's planing motion is very stable, and moves at a constant speed. In addition, the motion of foot is rhythmical and smooth in the comparison with beginner. As another example, motion analysis and evaluation that placed importance on motion of tools were performed. Sawing operation and making of hole with chisel and hammer were analysed. Various analyses can be executed from each tool position and posture, and skill evaluation can be expected.

Keywords: Traditional skills and techniques, preservation, succession, 3D-CAD, motion analysis

1. Introduction

Succession of the skills and techniques is very important in various fields. In Japan, a lot of special traditional skills which should be succeeded exist in many places. Succession of such traditional skills and techniques requires the relationship between master and successor. The master shows the skill and technique, and successor learns by repeating of practice for a long time. However, aging of these experts and shortage of successors became serious problem. Recently, succession of the skills and techniques is becoming difficult. Therefore, it is needed to be converted to datum with objectivity and reproducibility as Hiyama (2011). We propose the new preservation method by using datum based on multimedia. Here, multimedia means document, sketch, drawing, photograph, movie, voice, sound. Moreover we use 3D-CAD, CAE analysis and motion capturing technology; as new media. Figure 1 shows the conceptual diagram of this study. The purpose of this work is to propose a method for preservation

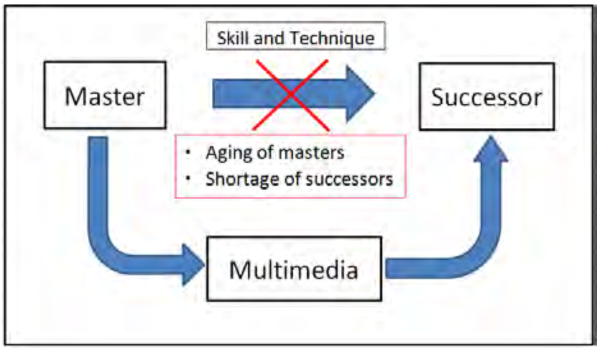

Figure 1 Conceptual diagram

of traditional skills and techniques to next generations by using new media and technology. In addition, quantitative evaluation of motion using implements or tools is difficult, because relations among body motion and posture of implements or tools are complicated. Therefore we also perform motion analysis and evaluation that placed importance on motion of tools.

2. Subject of study

A new preservation and succession method of traditional skills and techniques is developed by using data based on the multimedia. Japanese wooden ship “Tsunoshima-denma” ship; a traditional wooden ship made in Yamaguchi prefecture Hohoku town, was selected. From 2002 to 2003, "Tsunoshima-denma" ship was reproduced by a shipbuilder in Hohoku-town of Yamaguchi prefecture as a town event. In the shipbuilding, all processes were carefully observed and recorded by many staff for six months. The amount of recorded media is video tapes of 141 hours, 173 pages of notebooks including documents and sketches, great number of photographs. Then introducing digest video DVD (2003) and 197 pages of report (2997) were published by Hohoku-town. We decided to use these media materials to develop the preserving and learning method.
In the making process of Kawara structure (the bottom of a ship) of the ship, the traditional skill of coaptation of wood plate called “Hagiawase” is used. The “Hagiawase” is a technique to connect boards according to desired shape. It is a Japanese original technique applying in various fields. This technique uses a chisel and a hammer. We used motion capture system to preserve and analyze of movement of objects, such as a chisel or a hammer used in traditional skill and techniques. Figure 2 shows name of each part of wooden ship.

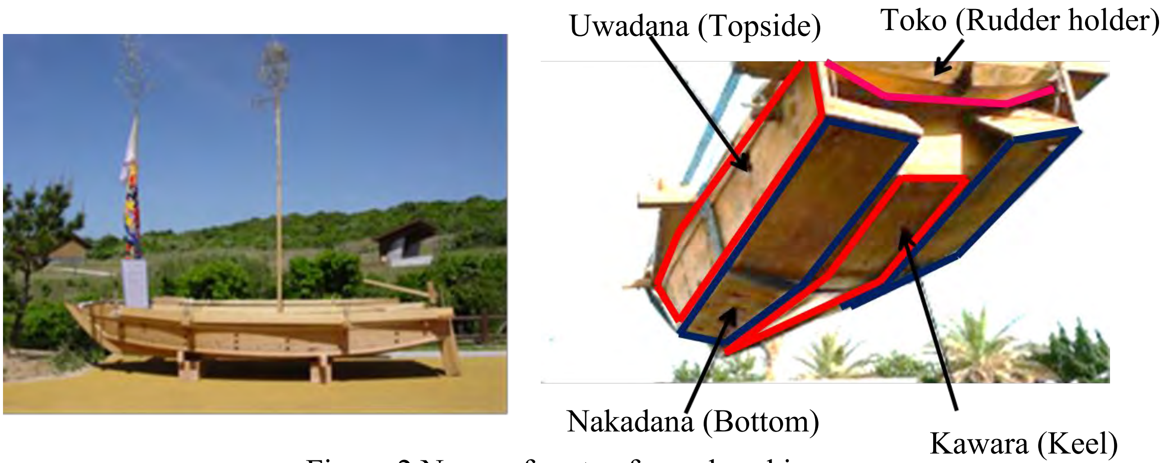

Figure 2 Name of parts of wooden ship

3. Preservation and succession of wooden ship making process using 3D-CAD

The wooden ship can be made by same way on 3D-CAD with actual fabrication as shown in Fig. 3. Each part of the ship were modeled and assembled in the similar way of the actual processes and dimensions. SolidWorks(TM) was used in this study. The sizes of each parts were decided by original drawing, and real ship dimensions measured by ourselves. Figure 3 shows an example of assembling parts. In this figure, (a) is the keel called Kawara, (b) and (c) show assembling of other parts into Kawara. In ordinary way using 3D-CAD, all parts are assembled after each parts modeling. But this way is not satisfy our purpose. We made 3D model as shown in Figure 3, parts modeling and assembling were simultaneously performed like real making processes.
The process of shipbuilding can be preserved as history tree by function of 3D-CAD, as shown in Fig. 4. In this data, the history of 3D-CAD model is included. The right side of the picture is history function of 3D-CAD. It is very important in this proposed learning process that the successor can learn shipbuilding process by using of this history tree. In this way, preservation and succession of

traditional skill and technique will be able to be achieved by new learning method proposed here using 3D-CAD. The learning database about the process and method of shipbuilding was expressed by using HTML format. The database consists of multimedia datum, including 3D-CAD model's data. Clicking these pictures, the detail data to understand shipbuilding process (document, movie, photograph, etc. and 3D-PDF model and 3D-CAD data) is shown on the display as our previous work; Shirakawa et al (2014). Figure 5 shows the actual "Tsunoshima-denma" ship and assembled 3D-CAD model. We can operate and change the ship angle on screen and can imagine the shape of the ship. This database can help apprentice (successor) to understand size and shape of the ship.
In addition, we can obtain analytical result about various engineering specification applying CAE analysis for the 3D-CAD model as shown in Fig. 6 by Shimizu et al (2014).

(a) (b) (c)

Figure 3 Assembling process similar with actual work

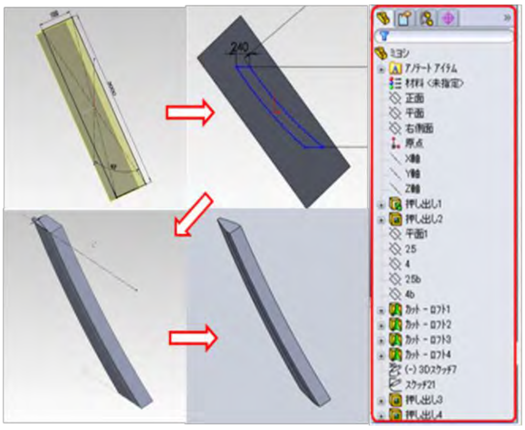

Figure 4 History function of 3D-CAD

Figure 5 Actual ship and 3D-CAD model

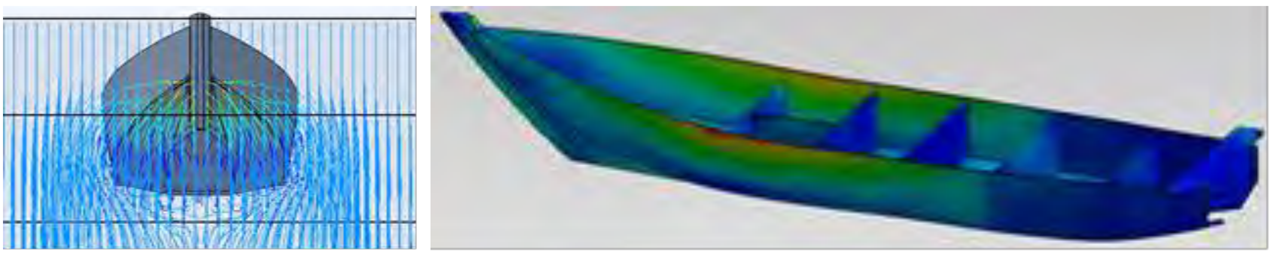

Figure 6 CAE analysis results; stream line (left) and stress distribution (right)

4. Motion analysis

4.1 Preservation of wood planing motion

As the first trial of motion analysis, planing operation of carpenter was examined. Though the difference of operation and the posture of the beginner and the expert can be confirmed in some degree with the unassisted eye, we tried to evaluate the difference quantitatively by using the captured data by Shirakawa et al (2015). Figure 7 shows the position change in 3-axis coordinates of the parietal region. Here, horizontal axis of this graph is flame number of motion data (100fps). X-axis is direction of plane motion, Y-axis is vertical direction and Z-axis is taken perpendicular to the plane motion. This graph includes the motions before planing and after planing motion, and the actual plane finishing motion is between 500-1300 frames. Focusing on the change of Z-axis, the head was moving at approximately constant speed during plane finishing motion. Moreover, it is also clear that there is almost no changes of horizontal (X) and vertical (Y) direction, and the head was moving parallel to the cutting face during about 3 or 4 steps of feet moving. Figure 8 shows tracks of feet. It is observed that the step of expert moves parallel to the direction of planing operation, avoiding the foot which he embarked on behind. Here, landing points of foot are shown with red circles. The landing point of the expert's feet is almost placed along a straight line.

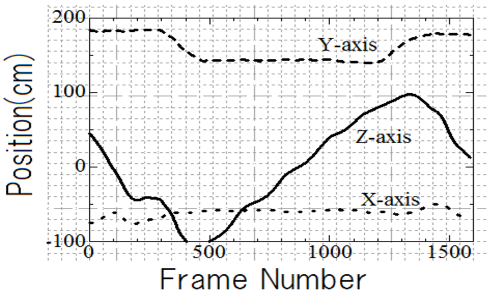

Figure 7 Change of head position

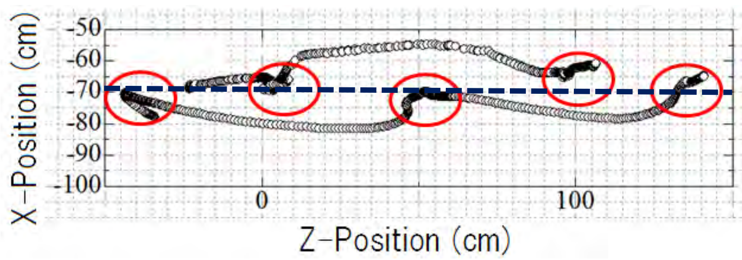

Figure 8 Tracks of feet moving in the skilled motion

4.2 Motion analysis of sawing operation

As the next step, we tried to examine an operation using tool. We treat sawing that is frequently used in wooden ship making process. Then, Table 1 and Figure 9 show definition of parameters in order to compare the motion of workers. Here, sawing motion of two operators is compared. We try to preserve the features and habits of master’s motion through the comparison. Operator A is experienced person of sawing. On the other hand, Operator B is beginner of sawing.

Table 1 Definition of parameters

No	Parameter	Definition
1	Velocity of right hand	Marker velocity of right wrist
2	Angle of elbow	Angle between humerus and forearm
3	Angle of saw	Engagement angle of wood and saw
4	Angle around wrist	Angle between forearm and hand
5	Angle around grip	Angle between right wrist and cutting edge

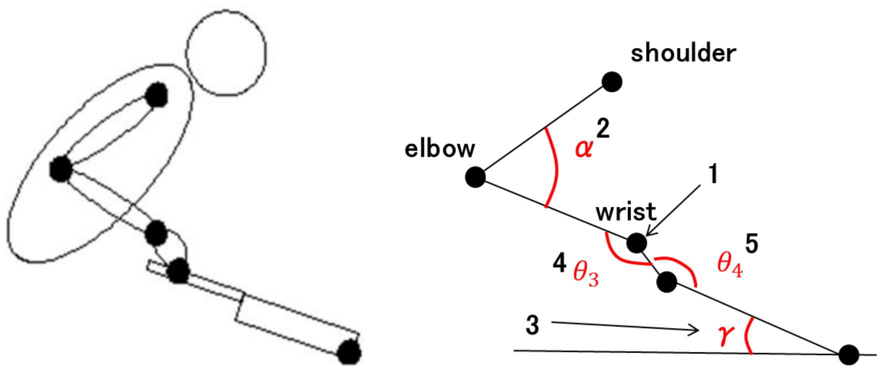

Figure 9 Definition of parameters

Angle change of elbow shows the difference of stroke and speed of motion in sawing. Figure 7 shows angle change of elbow of operator A and B. It is observed that the operator B shows quick and short stroke action compared with operator A. Figure 8 shows the invasion angle change of saw. In general, the angle of saw blade and material for efficient sawing is usually 30 degrees, and 45-60 degrees for hard material. In this way, invasion angle of saw blade affect the efficiency of cutting that is a main purpose in sawing. From these figures, operator A shows long stroke and constant rhythm, also invasion angle of saw blade is near 30 degrees.

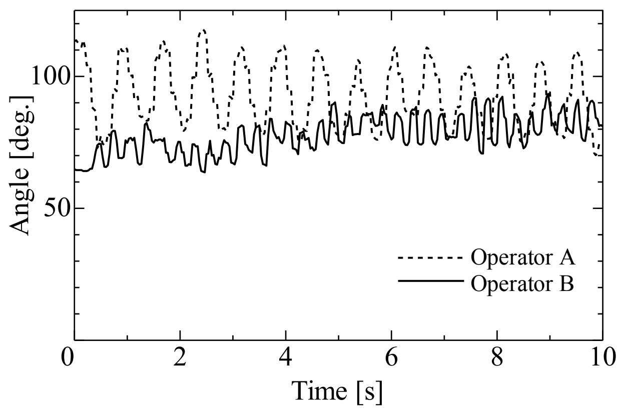

Figure 10 Change of elbow angle

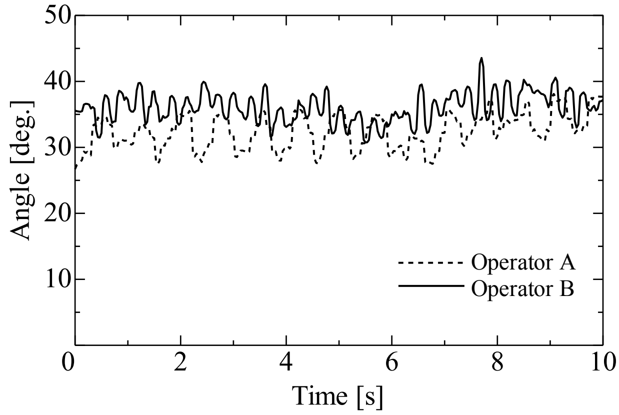

Figure 11 Change of invasion angle of saw blade

In order to evaluate periodicity in sawing motion, FFT analysis was applied to resultant waveform. Figure 12 shows the FFT analysis results for change of elbow angle (Figure 10) of operator A and B. Since a remarkable peak appeared in the results of operator A compared to operator B, there is a periodicity in the original waveform. Therefore, the motion of operator A is periodic with constant tempo. On the other hand, since there is no remarkable peak observed in the result of operator B, it can be said that the original waveform is almost no periodicity.

Furthermore, it is possible to obtain useful information about muscle power in the operation by combining measurement of myoelectric signal. Figure 13 shows a simultaneous measurement result of motion and myoelectric signal. Here, myoelectric signal were converted to %MVC (Maximal Voluntary Contraction), which is proportion of the actual value to maximum value of the muscle. This system can evaluate the relation between motion of human body and action of muscle. Therefore, it will become useful to undeastand muscle action in skilled motion and technique.

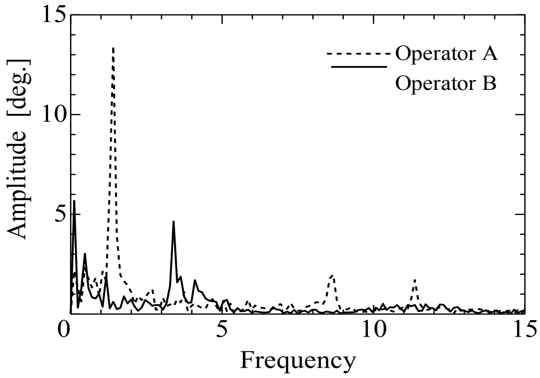

Figure 12 FFT analysis (Elbow angle)

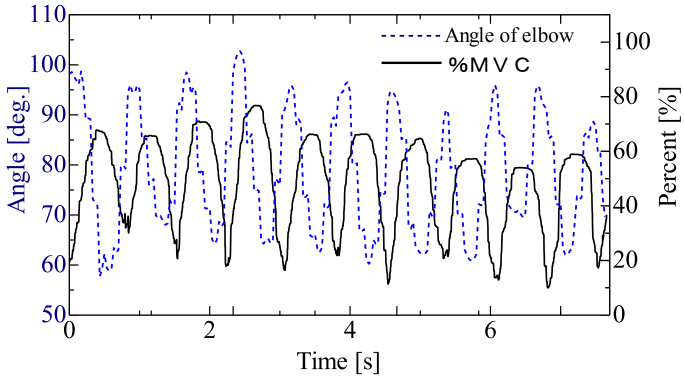

Figure 13 Simultaneous measurement results

5. Tool motion analysis in traditional skill

5.1 Traditional skill “Hagiawase”

Next, detail of work process of traditional skill called “Hagiawase” is explained below. First, the trapezoidal nail ditch called "Raki-hole" is dug. Next, a hole to guide a nail is dug into a wood board using a special tool called "Kugisashi-chisel". Finally, two boards are attached tightly, and a ship-nail is driven into the hole (Fig. 14). A series of these motions are performed in the "Hagiawase". To obtain the information of this operation, one of the authors practiced this technique for about two weeks. In this study, we paid attention to objects and tried to analyze about movement of tools, because motion analysis for human body has been already studied widely with various methods. Three markers were put on a chisel and a hammer respectively, to define it as rigid body as shown in Fig. 15. Various analyses can be executed from marker positions.

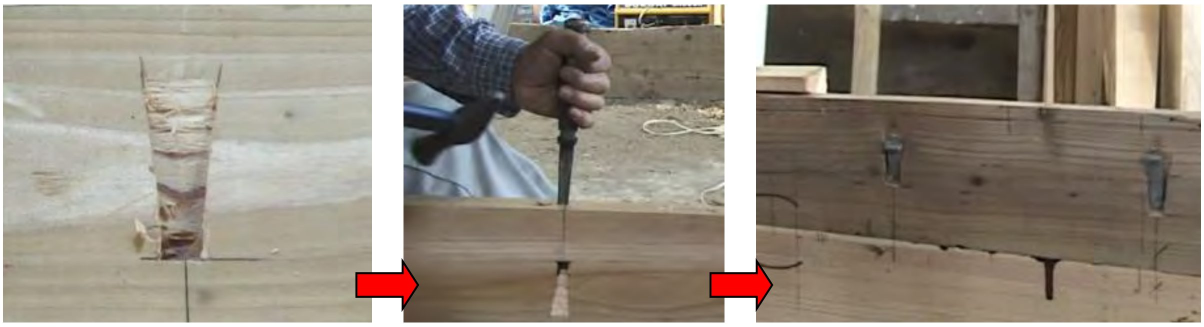

Figure 14 Traditional skill "Hagiawase"

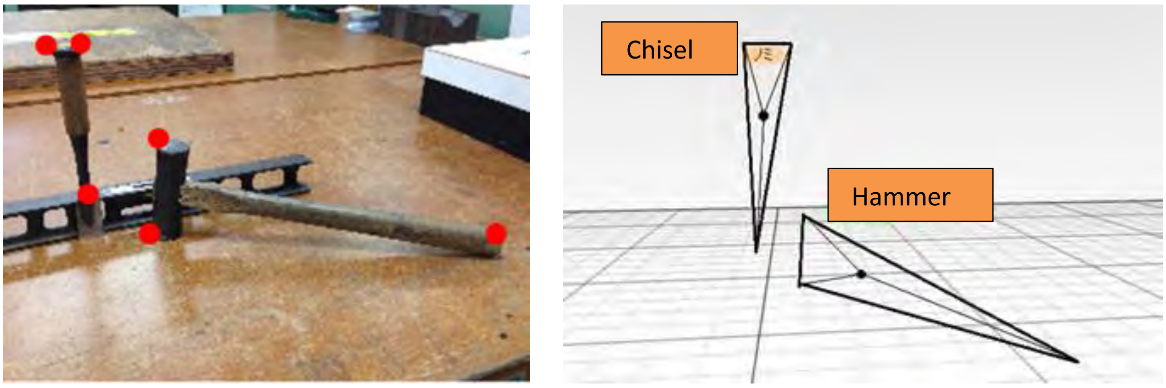

Figure 15 Model of chisel and hammer

5.2 Modeling on 3D-CAD (as an educational tool in database)

As described in previous section, we create the CAD model similar to actual process based on the existing data about traditional shipbuilding. The purpose is to preserve the work process in the history of CAD. We created the 3D-CAD model of actual ship and analysed it using CAE software as shown in section 3. In this study, we focused on the work process. We preserved the process from the beginning to the end of the modelling, rather than making model. Figure 16 shows the working process of "Hagiawase" reproduced using CAD software. This is also added into the database of educational tool.

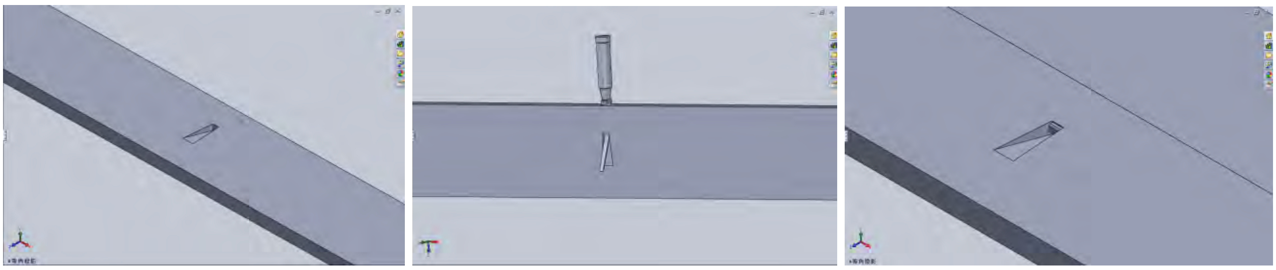

Figure 16 Working process of "Hagiawase"

5.3 Motion analysis results

An analysis result in the motion of process to make a "Raki-hole" is explained above. Value of direction cosine, which shows direction of a straight line in analytical geometry, is used. Here, α, β and γ are the angles of chisel axis direction to the orthogonal coordinate defined on the optical motion capture system. The cosine α is component of unit vector in x-axis direction. Also, cosine β and cosine γ are components of unit vector in y and z-axis direction respectively. Figure 17 shows the positional relationship between object and markers in three-dimensional coordinate.
Figure 18 shows the changes of three direction cosine values of the chisel axis. Using of direction cosines are effective means as the first step for motion analysis of objects. The posture of the chisel according to the time process can be judged from Figure 18.

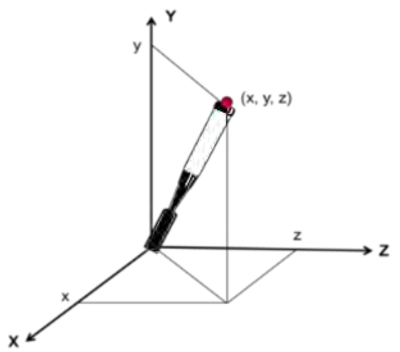

Figure 17 Positional relationship

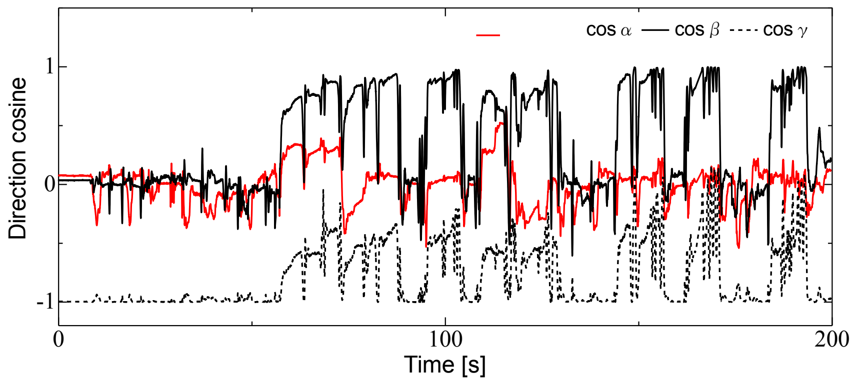

Figure 18 Change of direction cosine of chisel

In addition, Figure 19 shows changes of angle to Y-axis of the hammer head and the chisel axis, when the hammer strikes the chisel. Here, direction cosines were converted to angle to Y-axis. From this figure, it is observed that hammer is shaken down vertically when chisel is held vertically. However, the direction of hammer head axis shows different value from axial direction of chisel, when chisel is held diagonally. From this result, it is difficult for beginner to keep posture of tools to suitable direction in the operation. Figure 20 shows the difference in the angle of axial direction of chisel and velocity vector of hammer head at the moment of impact. The same thing is understood from this figure. It is very important to shake the hammer just to the chisel axis. But the velocity vector direction of hammer head is also largely different when chisel is held diagonally.
As a result, it is useful for evaluation of skillfulness by using analysis of tool motion, and is expected to be applied to training of skilled motion and technique.

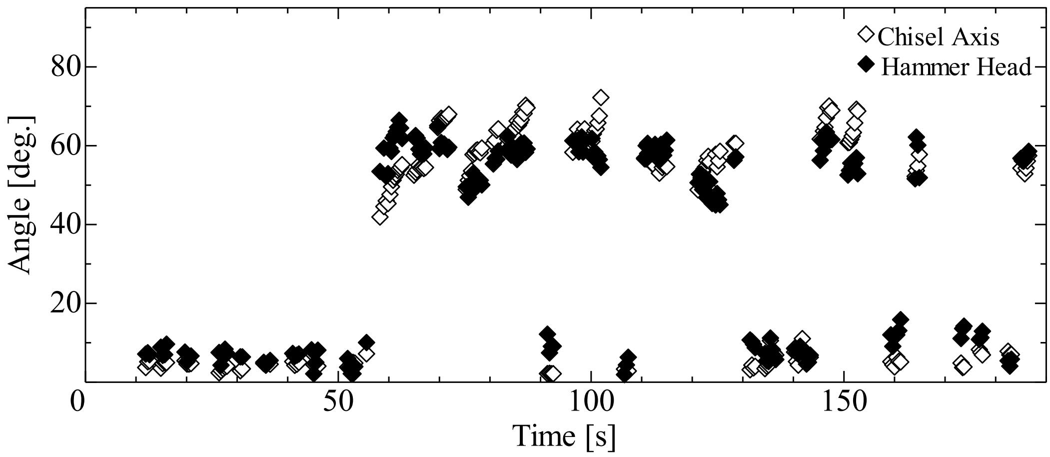

Figure 19 Angle of hammer head and chisel

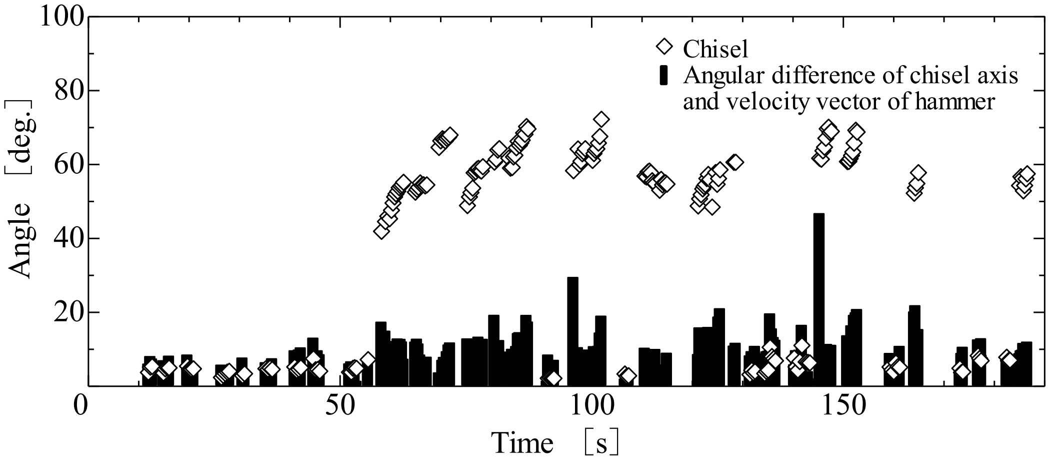

Figure 20 Angular difference between axial direction of chisel and velocity vector of hammer

6. Conclusion

3D-CAD model is meaningful because it can be made according to actual work process. Not only shape of each part but also processing and assembling procedure can be reconstructed. Quantitative evaluation of woodworking constructed based on experience is enabled by using CAE method. By motion analysis, the feature of the expert's stable operation is as extractive. The skilled operation will be able to be evaluated progressively by using more detailed analysis method. In addition, it is useful for evaluation of skilfulness by using analysis of tool motion, and is expected to be applied to training of skilled motion and technique. These results are useful and can be added to database of educational tool which we have constructed. For further progress of this study, it is necessary to think about suitable evaluation method for captured motion. Motion analysis of objects such as implements and tools is still not studied well. The motion analysis of objects should be examined in detail and be coupled with motion of human body as future work.

Acknowledgements

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Enhanced Learning and Employability of Engineering Students

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Abstract: This paper presents how Mechanical Engineering students/graduates in Sustainability/Energy Management area, or engineering students/graduates in generic terms, can enhance their employability, performance and engineering careers. It includes methods for gaining knowledge and expertise required for practicing junior consulting engineers, during studying at university. The benefits include:

- Increased opportunities for employment
- Increased confidence and shorter status as a junior engineer
- Better remuneration

The paper also addresses challenges and provides better understanding of requirements of modern energy management consulting practices. The proposed learning method can effectively be adopted in teaching engineering students by recognised energy management practising experts.

Keywords: Sustainability, Engineering Education, Cost effectiveness, Innovative Energy Management, Employability

Topic: **Ethics and Sustainability in Engineering Education**
Sub-Topic: Sustainability in engineering design

1.Introduction

Difficulties that engineering graduates face include:

- gap between learnings acquired at university and requirements at the workplace in order to achieve competency of a professional engineer,
- challenges of a competitive market,
- communication with recruitment agents,
- producing competitive CV,
- learning job interview techniques,
- selection of employers.

There is also a need to address issues of internship and a typical junior engineer status in that context. Many vital areas of competency required for graduate professional engineers need to be addressed, as there is a lack of focus of employers on integrated continual professional development (CPD) of junior staff beyond their business goals, leaving graduate engineers with a lot of uncertainties, frustration, reduced chance for a proper CPD, prospective employment and prolonged period, measured in years, with low salaries.

These shortcomings can be overcome through a structured, integrated approach at a university, by engaging practicing expert consultants as instructors or mentors, via a structured educational program (through tutorials, workshops & customised work experience) that would complement a standard curriculum.

2. Method

The method proposed in this paper considers implementation of an integrated practical professional engineer skill program, via completion of two modules:

MODULE 1 – In-class learning, provided by outsourced practicing senior consultants and expert professional engineers.

MODULE 2 - Structured work experience with selected consulting companies, and detailed guidance for students/graduates, leading to enhancing their employment opportunities.

Concept of learning involves: revisiting key theoretical concepts, gaining knowledge related to the requirements of relevant engineering market and consulting practices, and analysis of the most recent research on good practices, state of the art, applied to engineering projects, that follow the world most modern engineering sustainability trends. The projects demonstrate, in a transparent way, the most cost effective and innovative sustainability design, technologies and control strategies.

More specifically, this paper focuses on the importance of sustainable approach in Mechanical Engineering practice. For example, it is demonstrated through the cost effective control optimisations of computerised HVAC (Heating, Ventilation, and Air Conditioning) systems employed at commercial and other properties (office buildings, shopping centre, hospitals, art galleries, museums, public building, hotels and the likes), where in excess of 50% of energy is used by HVAC Services.

Return on investment on innovative energy efficient control optimisations is often measured in months, not years, which significantly increases their chances for approval and implementation.

However, the proposed method of learning is applicable to any engineering discipline.

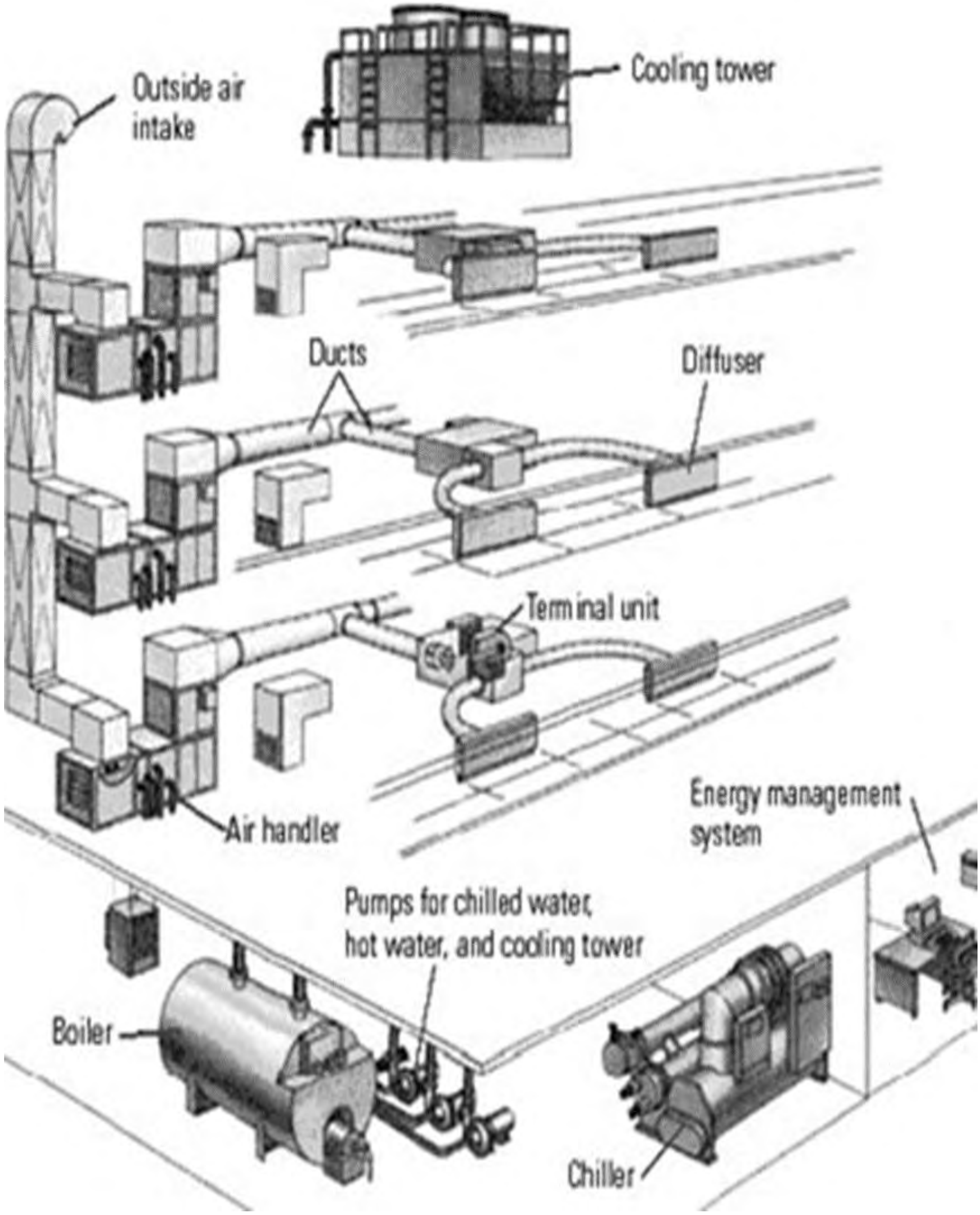
3. Details of the proposed structured educational program

Tutorial activities of MODULE 1 are very diverse, ranging from revisiting relevant key principles and various engineering skills, to understanding consulting environments, enhancing employment opportunities and expectations of future employers.

3.1 MODULE 1 - Tutorial Activities

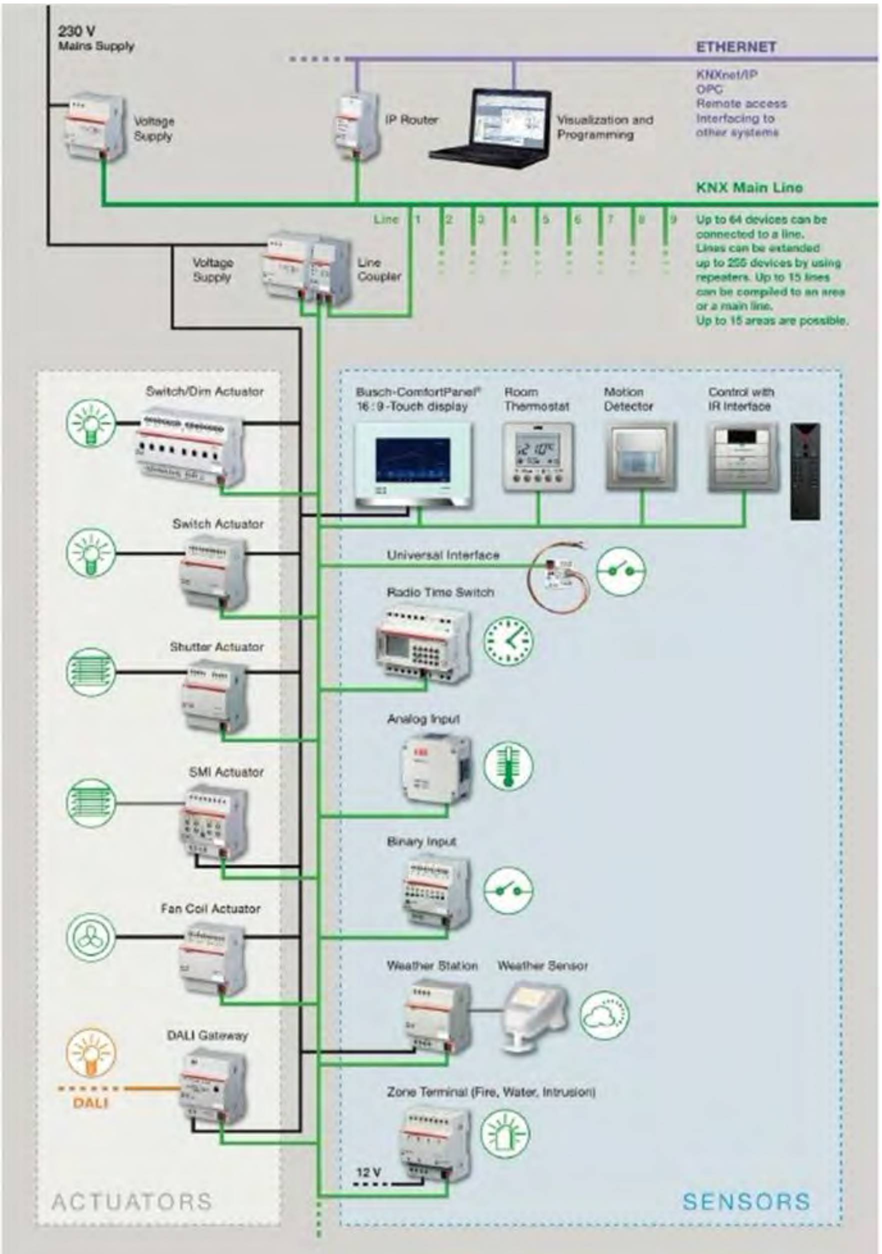
- **Revisiting Theoretical concepts – Phase 1** – Design of equipment - Revisiting basic thermodynamics principles required for understanding of basics of operations and design of HVAC (Heating, Ventilation and Air Conditioning) Systems – several workshops that would include analysis of various HVAC equipment and various HVAC design concepts, using project documentation (including the actual HVAC Design and energy audit reports of Sydney facilities – office buildings, museums, shopping centres, hotels, clubs). Selection of equipment - Heat load modelling using CAMEL ACADS BSG software.

- **Revisiting Theoretical concepts - Phase 2** – Design of controls – basics of HVAC Controls and analysis of various HVAC control concepts employed at the local facilities. Introduction of BMS Control concept – LAN schematics, BMS Point List, BMS Functional Description, graphics, alarms, etc.



Schematic 3.1 – Typical HVAC System for commercial properties – office buildings, public building, shopping centres, museums, art galleries, entertainment centres.

- **Advanced HVAC Control/BMS concepts** – with a focus on energy efficiency



Schematic 3.1.2 – Typical LAN (Local Area Network) BMS HVAC Control diagram

- **Basics of Energy Management** – topics would include: processing and analysis of energy interval and other energy data, sub-metering concepts, BMS trend logging, comfort conditions versus energy savings, energy saving calculations, estimation of capital costs and CO2 emissions, calculation of pay-back period and ROI. Basics of Measurements and Verifications (M & V Plan using IPMVP – International Protocol for creation of M & V plans). Creation of energy management daily check lists. Energy consumption modelling using ACADS BSG Beaver energy modelling program for typical commercial facilities. Basics of energy performance and understanding NABERS Ratings.

- **Basic Australian Standards and other regulations related to HVAC Design and Energy Management**- AS 1668.2 (Ventilation Code), AS 3598 (Energy Auditing), AS 3666 (Cooling Towers), BCA – Section J.

- **Basics of HVAC Equipment and Control Maintenances** – typical scope of works, typical operational, comfort and energy management issues encountered with HVAC and BMS maintenances, and rectification measures.

- **Commissioning of energy management/energy efficiency** projects – importance, typical issues and rectification measures.

- **Basics of energy auditing** – scope of work, planning and execution – request for various information/documentation, site visit, induction and WH & S requirements, communication with various parties (Facility Management, internal and external maintenance contractors, admin personnel, security, etc), expected issues and how to resolve them, observations, measurements, engineering, financial and environmental analysis, and writing reports.

- **MS Word, Excel and PowerPoint -** Minimal requirements.

- **Advanced Design and Energy Management concepts** – analysis of implemented projects and necessity for an ongoing consulting support to clients.

- **Enhancing career opportunities** – **Consulting environment** - Overview of nature and operations of consulting companies including their set of expectations.

- **Consulting office environment: non – engineering aspects** – team environment – administration requirements, behavioural standards, working hours, clothing, verbal and written communication, soft and hard documentation, hierarchy, DOs and DONTs.

- **Consulting office environment: engineering aspects** – working in a team environment including effective communication and productive collaboration when planning and implementing a project. Typical responsibilities and requirements in an engineering role. Overview of general expectations from young engineers in a professional role- importance of understanding given instructions and asking for clarifications/support initially and on an ongoing basis. What is required to be perceived by management as a good worker and a colleague?

- **Understanding receivers of services - Clients** – overview of typical clients and their representatives – expectations, site visits, meetings and communication. Request for information. Smooth project management. Typical issues and rectification measures. Professional conduct.

- **Consideration of various engineering memberships** – EA, ASME, AIRAH, ASHRAE, - pros and cons.
- **Expected additional qualifications and professional memberships** – EA, NABERS, ASHRAE, EEC.

- **Importance of Continual Professional Development** - Use of Internet, networking, employers' educational programs, publications, seminars, conferences, etc.

3.2 MODULE 2 - Work experience and enhancement of opportunities for employment

- Work Experience content negotiated with consulting companies, as a part of university course, which includes development of students' skills, contributing to their capability as future professional engineers.

- Preparation of and participation in actual projects – various phases which maximise exposure to the above engineering and non-engineering aspects of consulting environment, with the aim to acquire a set of targeted/planned engineering skills, from Junior to Senior Engineer.

- Preparation of CV, negotiation technique with recruitment agents, preparation for job interviews.

4. Conclusions

Implementation/Trial of the proposed educational program for engineering students is recommended. Expected outcomes of the proposed enhanced learning are:

- Students/graduates will acquire practical knowledge and expertise required of a professional engineer while studying at a university, and thereby enhance their future employment opportunities.

- Students/graduates will better understand operations and requirements of consulting environment in engineering and non-engineering terms, and therefore become confident to fulfil junior engineer role and to understand the key aspects of intermediate & senior engineer functions.

Whilst this paper is focused on Mechanical Engineers specialised in Energy Management Area, the concept can generally apply to any other engineering discipline.

Acknowledgements
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Teaching and Learning of Advanced Statistical Hydrology using a Blended Learning Approach: A Case Study in Western Sydney University

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Abstract: This paper presents delivery of Advanced Statistical Hydrology unit by the blended learning approach in Western Sydney University (WSU) as a part of the Master of Engineering degree. It has been found that blended learning is quite effective in delivering the contents of the Advanced Statistical Hydrology unit to Masters students. The unit consisted of two face-to-face workshops (total 5-hour duration) and eleven pre-recorded tutorial sessions (placed on the online system of WSU known as vUWS). The recorded tutorial sessions were found to be the most useful element of this unit as these allowed a student to listen to the recorded materials as many times as needed, and at the time when it is convenient to him/her. The preparation of a critical literature review was found to be the most difficult task for the students. It has been found that two workshops are insufficient to deliver the unit contents effectively to students, and hence it is proposed that a 2-hour workshop be delivered every fortnight to answer students' queries and facilitate face-to-face engagement among the students themselves and between the students and lecturer to enhance learning of this unit more effectively. This will make the blended learning approach more effective to the students for Advanced Statistical Hydrology unit in WSU in future years.

Keywords: Engineering education, Statistical Hydrology, blended learning, hydrology

1. Introduction

Water is the vital source of life on planet Earth, and the ever increasing water demand and its intrinsic relationship with the environment have made water as a subject of study in many disciplines of knowledge (Gleick, 1998; Grimmond, 2010). In Civil and Environmental engineering degrees, water-related subjects constitute a significant part, which generally include Fluid Mechanics, Surface Water Hydrology, Hydraulics, Statistical Hydrology, Hydrogeology and Water Resources Engineering. Hydrology is one of the most important water engineering subjects in Civil and Environmental engineering degrees all over the world. Hydrology, a Greek word that means "Science of Water" (Raudkivi, 2013) and is defined as "a branch of natural science concerned with occurrence, properties, distribution, and movement of water in the natural and man-made environment" (Elshorbagy, 2005).

One of the major focuses of the hydrological community is to train and educate hydrologists who can solve complex hydrological problems by having an interdisciplinary vision to the major hydrological issues (McGlynn et al., 2010). The grasping of the concept of hydrology appears to be a difficult task to numerous engineering students due to its empirical and conceptual nature. The qualitative and judgemental aspects of hydrological problems make them relatively difficult for engineering students who are used to solving problems using deterministic methods. It is essential for engineering students to comprehend the physics of hydrological processes before jumping on calculations (Raudkivi, 2013), which is not well appreciated by many students enrolled in engineering hydrology courses. The general difficulties in learning hydrology for Civil Engineers have been discussed by a number of previous researchers (e.g. Elshorbagy, 2005; Aghakouchak and Habib, 2010; Ngambeki et al., 2012).

Blended learning is one of the most efficient learning strategies as noted by the American Society for Training and Development, which rated this as one of the top ten trends to emerge in the knowledge delivery industry (Bonk and Graham, 2012). Rahman (2016) and Rahman and Al-Amin (2014) adopted a blended learning approach to deliver Fluid Mechanics unit in Western Sydney University (WSU). The method was extended to Advanced Statistical Hydrology unit in WSU as presented in this paper.

Advanced Statistical Hydrology is one of the core subjects in the Master of Engineering (Civil and Environmental) course in WSU. This unit covers statistical methods as applied to solving hydrological problems. In this paper, the opportunities and challenges faced by students and lecturers in learning and teaching of Advanced Statistical Hydrology by blended learning approach are discussed and recommendations are made for future improvement of the delivery of this unit.

2. Overview of Advanced Statistical Hydrology Unit in WSU

Advanced Statistical Hydrology unit (Code of 301014) is a Level 7 postgraduate unit in the Master of Engineering (Civil/Environmental) curriculum in WSU, which is coordinated by the third author of this paper. The unit is worth 10 credit points. The delivery of the unit started in 2015 and a blended learning approach was adopted to teach this unit that consisted of two face-to-face workshops during the semester, nine tutorial videos and hand-made tutorial solutions on papers accessible on vUWS. The unit consisted of at-site flood frequency analysis, regional flood frequency analysis, trend analysis of hydrological data, linear regression analysis and multivariate statistical techniques to solve advanced hydrological problems.

In order to pass this unit, students should complete three different assessment tasks and achieve an overall 50% mark (shown in Table 1). The first assessment task consisted of a 2000-word critical literature review report on a specified topic with the weighting of 25% that has to be completed by the students individually. The second assessment is an oral presentation with the same weighting of 25% on specified topics. The third assessment is a design project (4000-word length) with the weighting of 50%. Three assessments tasks are designed to test the students' knowledge achieved in 12-week period of study, which must satisfy WSU graduate attributes. It is expected that the students completing this unit would be able to solve complex hydrological problems using advanced statistical methods.

3. Student's perspective

The first author of the paper completed the Advanced Statistical Hydrology unit at WSU in 2015 and achieved a High Distinction grade (> 85% mark). He found the blended learning approach to be an effective method of learning the contents of this unit. He found the recorded videos for each of the tutorial problems to be very useful in understanding the fundamental issues with the problem i.e. what are the relevant assumptions associated with the solution and how much confidence can be placed on the given solution. The lecturer took plenty of time in solving a problem using a step by step procedure, which can be followed by any student without much difficulty. His teaching style was phenomenal and simplistic that makes difficult topics quite easy to understand. He did not leave any stone unturned to make the solution enjoyable by students where he provided numerous real world examples to clarify difficult concepts.

Table 1 Details of assessments in Advanced Statistical Hydrology Unit in WSU

Advanced Statistical Hydrology		
Assessment	**Type**	**Weighting**
1	Critical Literature Review (2000-word length). Individual report by students analyzing about 10 refereed journal papers on a topic allocated randomly to a student. Students should learn how to prepare a critical literature review report and how to use references in a scientific document.	25%
2	Oral Presentation. A 30-minute long oral presentation before the class by individual students on a topic (allocated randomly). Students should learn how to make a professional presentation on a scientific topic and how to answer questions professionally.	25%
3	Design Project. A 4000-word design project on a real world hydrological problem that needs knowledge of statistical methods covered in the workshop and tutorial VDOs of the unit. Student should learn how to design a hydrological project and how to write a professional design report.	50%

The second important aspect of this unit was oral presentation where the lecturer and the fellow students got plenty of time (about 10 minutes) to ask relevant questions on the topic. The feedback by the lecturer on the oral presentation was found to be quite useful e.g. do not use long sentences/paragraphs in slides, give adequate references to each figure and table (taken from other sources), and make an interesting background and clear objectives of the presentation.

The third aspect of learning was how to make in-text references and the chapter-end list of references which were not obvious to many students in the unit. The lecturer was astonished that many students do not know how to prepare a list of references in an acceptable manner. The fourth aspect of the unit was two face-to-face workshops (two and three hours' durations respectively) where students got the opportunity to ask questions relevant to the subject matter to the lecturer. This also allowed intellectual discussion among fellow students, which were an interesting component of this unit.

4. Lecturer's perspective

The third author of the paper was the lecturer and coordinator of Advanced Hydrology unit in WSU in 2015 (spring semester). He developed the learning materials of the unit in autumn semester 2015 so that the delivery of the unit in the following spring session could be implemented smoothly. He found that development of the unit is quite challenging by the blended learning approach as it needed a great deal of time to develop online materials. The Blended Learning Team of WSU assisted in recording the tutorial classes. A graphics tablet was used to record the tutorials that included oral explanation and graphical illustration for a given problem. This is a computer input device, which enables a user to hand-draw images, animations and graphics, with a special pen-like stylus (as shown in Figure 1). Eleven tutorials were recorded in this unit, which were then posted in the web. There was no face-to-face tutorial class in the unit delivery. A total of 22 hours were spent in recording the tutorials by the development team consisting of the lecturer and Blended Learning Team of WSU (second author of the paper).

Figure 1 Graphics tablet used to record tutorial sessions in Advanced Hydrology Unit in WSU

There were six students in the class in 2015. The total watch time of the online tutorials was 2,684 minutes by the six students (average 7.45 hours per student). The total number of views by the six students was 458 i.e. 76 views by a student on average. The tutorial access rate by the students is illustrated in Figure 2, which shows that the accesses rates were peaked before the project submission dates.

The students struggled in writing the critical literature review report. The references (both in-text and chapter end) were not consistent for the majority of the students. In oral presentation, some students included only the basic and intermediate information on the topic without providing advanced/latest materials from high quality journal papers. Students had a tendency not to quote the references for the figures and tables taken from other sources. The lecturer (third author) felt that two workshops were inadequate to deliver the unit contents to the students. Also, without any formal examination; the students were reluctant in mastering the topics contained in this unit. In the design project, a good number of students could not apply the right statistical techniques to solve the given hydrological problem, which indicated a lack of competence in the subject matter.

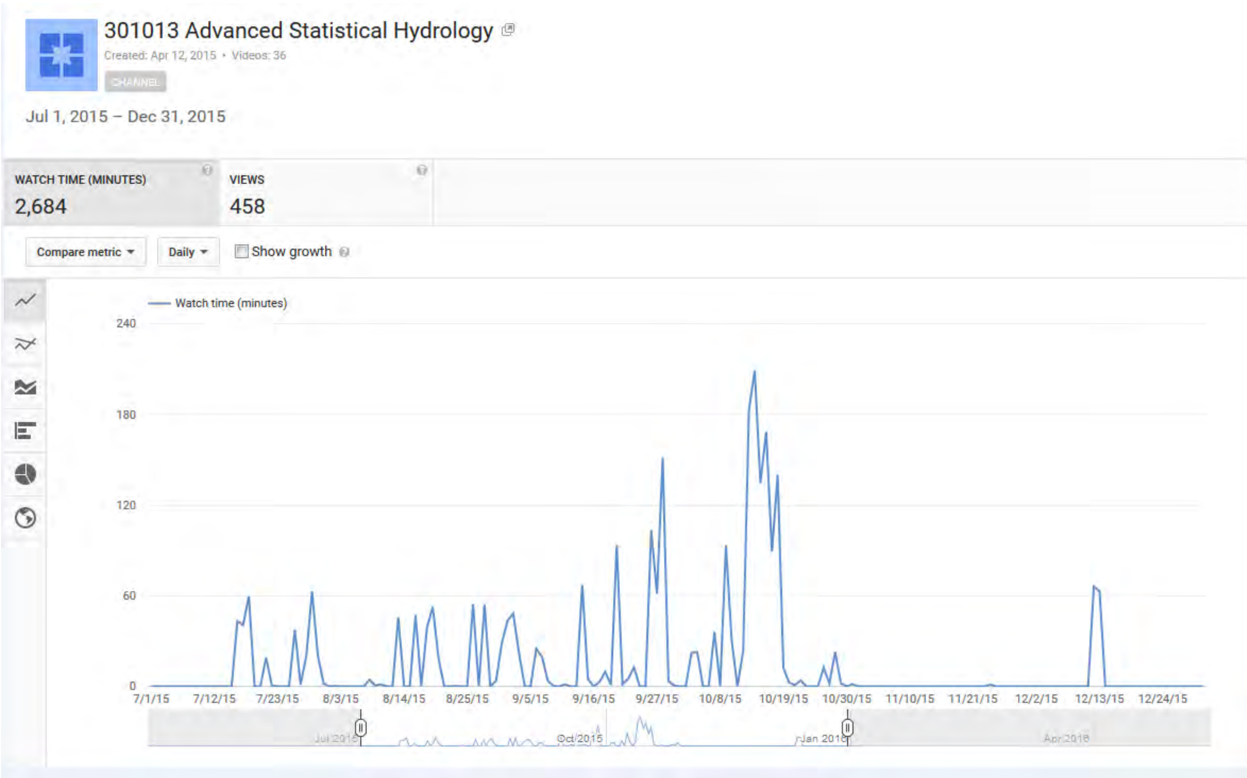

Figure 2 Tutorials access rate by students for Advanced Statistical Hydrology Unit in WSU (2015)

5. Conclusion

This paper presents delivery of Advanced Statistical Hydrology unit in Western Sydney University (WSU) as a part of Master of Engineering degree. It has been found that blended learning is quite effective in delivering this subject to Masters level students. The recorded tutorial videos were found to be the most useful element of this unit as these allowed a student to use the materials as many times as needed, and more importantly, at the time when it is convenient to him/her. The preparation of critical literature review was found to be the most difficult task to the students. As further development in the delivery of this unit, the assessment should include a two-hour long formal closed book examination to ensure that students have learned the subject matter with required competence. It has been found that two workshops are insufficient to deliver the unit contents effectively to the students, and hence it is proposed that two hours workshops be delivered every fortnight to answer students' queries and facilitate face-to-face engagement among the students themselves, and between the students and lecturer. This will make the blended learning approach more effective to the students in Advanced Statistical Hydrology unit in WSU in future years.

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A Personalized Learning System to Address Background Deficiencies and Highlight the Value of Digital Logic

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Abstract: This paper presents the development of a novel, web-based, adaptive learning system to teach digital logic. The system provides personalisation of learning by adapting the material to the competence level and interests of the student. The system is based on an automatic adaptive learning strategy that contains banks of online quiz questions of varying difficulty. As students answer questions correctly they are given more challenging questions. If students answer questions incorrectly, they are given easier questions. The current competence level of the student is determined by their performance on these questions and the corresponding level of course material is then presented. In this way, students that require additional time on foundational material can build competence on their own while students that excel at the material can move toward advanced concepts more rapidly. We build upon this system by considering the demographics of the student in order to make the material more relevant to the user. Research in the field of social psychology has shown that the choice of application to illustrate the engineering concepts can dramatically increase interest in the subject by certain student demographics. An e-learning environment provides a unique opportunity to reinforce the application of the material since the student is engaged with the system already. This paper describes the development of our system, the data collected to measure baseline student understanding, a pilot study of a small-scale implementation of the adaptive learning system, and the future plans to include demographics specific applications of the material.

Keywords: Engineering education, adaptive learning, personalized learning, student motivation, retention, professional formation

1. Introduction

The use of technology-based instruction is revolutionizing pedagogical practices in higher education (Enriquez, 2010, Figlio, 2010, Means, 2010). In the past decade, there has been a rapid advance in the number and quality of tools available to create multimedia course content and develop automated assessment measures. This has allowed instructors to move lower levels of learning such as knowledge-transfer and comprehension outside of the live lecture period and use in-class time to focus on higher order learning. This has also allowed instructors to create formative and summative assessment tools that can be automatically graded by course management systems. This reduces the amount of time that instructors have to spend grading and allows them to focus more on working with students and developing course content. The *flipped classroom* is the classic example of this type of educational revolution enabled by technology (Bishop, 2013).

While spending class time and instructor focus on higher order learning is the desired allocation of resources, it magnifies background deficiencies of some students. This is especially apparent in introductory-level courses where college preparedness can vary widely. Students with background deficiencies are often ill-equipped to learn lower level skills on their own using multimedia course content such as videos or web-based tutorials. They also may lack the pre-requisite knowledge to comprehend the new material on their own. This leaves struggling students with no support as higher education moves more heavily toward flipped classrooms and problem-based learning (Aydin 2016). This creates an ironic scenario in which technology-enhanced instruction actually widens the gap between adequately prepared students entering college and those with background deficiencies. However, the solution to this issue can also be addressed with technology through a personalized learning environment to specifically target the student's deficiencies and automatically guide them through activities to bring them up to proficiency. This type of personalized, *adaptive learning system* has the potential bring up the ill-prepared students to a proficient level without using precious instructor time (Brusilovsky, 2003, Munoz-Merino, 2011).

One of the exciting aspects of deploying a personalized learning system is that the students are already engaged within the environment so additional educational components can easily be added. The obvious component that this systems can include is advanced material for the higher performing students. An initial assessment of understanding can be administered to determine whether a student is either deficient or proficient. Those that are deemed immediately proficient can bypass the activities to address deficiency and can engage in content that targets higher order thinking. Another exciting aspect of a personalized learning system is the ability to stress the *affective* learning domain. This may include stressing the application of the material or demonstrating the relevance of it in modern society. Research in social psychology has shown that the *value* of a profession is a predictor of motivation to persist in the degree for certain student demographics. It has been shown that underrepresented minorities and first generation college students are more motivated to pursue and persist in professions that are seen as having *communal* value, or ones that help others and/or community (Smith, 2007, Seymour, 1997, Metz, 1999). This line of research has also shown that the interventions needed to show that a profession has communal value are relatively straight forward to implement. Something as simple as using an application that inherently *helps others* in examples and homework problems can have a large impact on a student's impression about the profession (Metz, 2011). This is especially effective if the communal value of the material is stressed repeatedly throughout the course. A personalized learning system has the potential to dynamically change the type of application used to teach the concept to match the background of particular students in addition to continuously reinforcing the value of the profession to society. This allows the affective learning domain to be stimulated without using instructor resources.

This paper presents an overview of a personalized learning system that is in development at Montana State University (MSU) that focuses on a set of introductory-level digital logic courses. This system is part of a long term project to deploy a nationwide, e-learning system to address background deficiencies of incoming freshman, facilitate mastery for top performing students, and include demographic-specific applications in order to stimulate the affective learning domain. This system will stress the communal value of the content in order to improve motivation of underrepresented minority students and first generation college students to persist in computer science and engineering. This paper presents the development of a detailed set of learning objectives that have been developed for digital logic in addition to the measures used to collect a baseline of understanding prior to the implementation of the adaptive learning algorithm. We then present the algorithm itself and a pilot study of the system for one of the learning outcomes that had the lowest level of performance in the baseline. Finally, we present the approach that will be used to stimulate the affective learning domain by using *Everyday Examples of Engineering (E^3)* (Metz, 2011).

2. Method

2.1 Learning Outcomes for Digital Logic

The first step in the development of the personalized learning system was to create a set of specific learning outcomes to be measured. The learning outcomes were developed to cover a sequence of two courses in digital logic at the sophomore and junior level. One or both of these courses are required in most ABET accredited undergraduate degrees in the U.S.A. Since these courses are widely used, there is a general consensus about the type of content that is typically covered in them (Herman, 2010, Goldman, 2010). Figure 1 shows the 55 specific learning outcomes developed for teaching digital logic at an introductory level. The outcomes are grouped into 13 modules, which each represent an overarching learning *objective*. Modules 1-7 are typically covered in a 200-level course and modules 8-13 are typically covered in the 300-level course, although delivery approaches may vary at different universities.

Learning Objective	**Learning Outcome**	**Learning Category**					
The overall learning goal of this module is to:	*After completing this module, a student will be able to:*	**1**	**2**	**3**	**4**	**5**	**6**
Module 1: To understand the basic principles of analog and digital systems.	**1.1:** Describe the fundamental differences between analog and digital systems.	x					
	1.2: Describe advantages of digital systems compared to analog systems.	x					
Module 2: To understand the basic principles of binary number systems.	**2.1:** Describe the formation and use of positional number systems.		x				
	2.2: Convert numbers between different bases.			x			
	2.3: Perform binary addition and subtraction by hand.			x			
	2.4: Use two's complement numbers to represent negative numbers.			x			
Module 3: To understand the basic electrical operation of digital circuits.	**3.1:** Describe the functional operation of a basic logic gate using truth tables, logic expressions, and logic waveforms.	x					
	3.2: Analyze the DC and AC behavior of a digital circuit to verify it is operating within specification.				x		
	3.3: Describe the meaning of a logic family and the operation of the most common technologies used today.	x					
	3.4: Determine the operating conditions of a logic circuit when driving various types of loads.				x		
Module 4: To understand the basic principles of combinational logic design.	**4.1:** Describe the fundamental principles and theorems of Boolean algebra.		x				
	4.2: Analyze a combinational logic circuit to determine its logic expression, truth table, and timing information.				x		
	4.3: Synthesis a logic circuit in canonical form (Sum of Products or Product of Sums) from a functional description.					x	
	4.4: Synthesize a logic circuit in minimized form (Sum of Products or Product of Sums).					x	
	4.5: Describe the causes of timing hazards in digital logic circuits and the approaches to mitigate them.		x				
Module 5: To understand the basic principles of hardware description languages.	**5.1:** Describe the role of hardware description languages in modern digital design.		x				
	5.2: Describe the fundamentals of design abstraction in modern digital design.		x				
	5.3: Describe the modern digital design flow based on hardware description languages.		x				
	5.4: Describe the fundamental constructs of VHDL.		x				
	5.5: Design a VHDL model for a combinational logic circuit using concurrent modeling techniques.					x	
	5.6: Design a VHDL model for a combinational logic circuit using a structural design approach.					x	
	5.7: Describe the role of a VHDL test bench.		x				
Module 6: To understand the basic principles of medium scale integrated circuit logic.	**6.1:** Design a decoder circuit using both the classical digital design approach and the modern HDL-based approach.				x		
	6.2: Design an encoder circuit using both the classical digital design approach and the modern HDL-based approach.				x		
	6.3: Design a multiplexer circuit using both the classical digital design approach and the modern HDL-based approach.				x		
	6.4: Design a demultiplexer circuit using both the classical digital design approach and the modern HDL-based approach.				x		
Module 7: To understand the basic operation of sequential logic circuits.	**7.1:** Describe the operation of a sequential logic storage device.		x				
	7.2: Describe sequential logic timing considerations.		x				
	7.3: Design a variety of common circuits based on sequential storage devices.					x	
	7.4: Design a finite state machine using the classical digital design approach.					x	
	7.5: Design a counter using the classical digital design approach and using an HDL-based, structural approach.					x	
	7.6: Describe the finite state machine reset condition.		x				
	7.7: Analyze a finite state machine to determine its functional operation and maximum clock frequency.				x		
Module 8: To understand the full capability of hardware description languages.	**8.1:** Describe the behavior of a VHDL process and how it is used to model sequential logic circuits.		x				
	8.2: Model combinational logic circuits using a process and conditional programming constructs.					x	
	8.3: Describe how and why signal attributes are used in VHDL models.		x				
	8.4: Design a finite state machine using the classical digital design approach.					x	
	8.5: Describe the capabilities provided by the most common VHDL packages.		x				
Module 9: To understand how hardware description languages can be used to create behavioral models of synchronous digital systems.	**9.1:** Design a VHDL behavioral model for a sequential logic storage device.					x	
	9.2: Describe the process for creating a VHDL behavioral model for a finite state machine.		x				
	9.3: Design a VHDL behavioral model for a finite state machine.					x	
	9.4: Design a VHDL behavioral model for a counter.					x	
	9.5: Design a VHDL register transfer level (RTL) model of a synchronous digital system.					x	
Module 10: To understand the basic principles of semiconductor-based memory systems.	**10.1:** Describe the basic architecture and terminology for semiconductor-based memory systems.		x				
	10.2: Describe the basic architecture of non-volatile memory systems.		x				
	10.3: Describe the basic architecture of volatile memory systems.		x				
	10.4: Design a VHDL behavioral model of a memory system.					x	
Module 11: To understand the basic principles of programmable logic	**11.1:** Describe the basic architecture and evolution of programmable logic devices.		x				
	11.2: Describe the basic architecture of Field Programmable Gate Arrays (FPGAs).		x				
Module 12: To understand the basic principles of binary arithmetic circuits.	**12.1:** Design a binary adder using both the classical digital design approach and the modern HDL-based approach.					x	
	12.2: Design a binary subtractor using both the classical digital design approach and the modern HDL-based approach.					x	
	12.3: Design a binary multiplier using both the classical digital design approach and the modern HDL-based approach.					x	
	12.4: Design a binary divider using both the classical digital design approach and the modern HDL-based approach.					x	
Module 13: To understand the basic principles of a computer system.	**13.1:** Describe the basic components and operation of computer hardware.		x				
	13.2: Describe the basic components and operation of computer software.		x				

Figure 1 Learning Outcomes in Digital Logic Developed for this Project

Also shown in figure 1 is the category of learning for each outcome. These categories come from Bloom's Taxonomy of cognition (Bloom, 1956) and represent lower vs. higher level learning. The coding of categories in figure 1 is: 1=Knowledge; 2=Comprehension; 3=Analysis; 4=Application; 5=Synthesis; and 6=Evaluation. It is important to keep in mind the learning category of each outcome when developing the assessment measures so that the tools are measuring the correct level of cognition (i.e., a synthesis outcome should have an assessment tool that measures synthesis and not a lower level category such as comprehension).

2.2 Assessment Tools

Over 600 instruments were developed to measure student performance on these outcomes. These included multiple choice questions measuring knowledge, comprehension, and analysis in addition to word problems to measure application and design problems to measure synthesis. The following figure shows an example of the types of instruments that were developed in this work.

4.3.49 For the 4-input maxterm list in Figure 4.38, give the canonical sum of products (SOP) logic expression.

$$F = \prod_{A,B,C,D}(3,7,11,15)$$

Figure 4.38

4.3.50 For the 4-input maxterm list in Figure 4.38, give the canonical sum of products (SOP) logic diagram.

4.3.51 For the 4-input maxterm list in Figure 4.38, give the minterm list.

4.3.52 For the 4-input maxterm list in Figure 4.38, give the canonical product of sums (POS) logic expression.

4.3.53 For the 4-input maxterm list in Figure 4.38, give the canonical product of sums (POS) logic diagram.

4.3.54 For the 4-input maxterm list in Figure 4.38, give the truth table.

Section 4.4 –Logic Minimization

4.4.1 For the 2-input truth table in Figure 4.39, use a K-map to derive a minimized sum of products (SOP) logic expression.

A	B	F
0	0	0
0	1	1
1	0	0
1	1	1

Figure 4.39

4.4.2 For the 2-input truth table in Figure 4.39, use a K-map to derive a minimized product of sums (POS) logic expression.

4.4.3 For the 2-input truth table in Figure 3.39, use a K-map to derive a minimized sum of products (SOP) logic expression.

1	0	0
1	1	0

Figure 4.42

4.4.8 For the 2-input truth table in Figure 4.42, use a K-map to derive a minimized product of sums (POS) logic expression.

4.4.9 For the 3-input truth table in Figure 4.43, use a K-map to derive a minimized sum of products (SOP) logic expression.

A	B	C	F
0	0	0	0
0	0	1	1
0	1	0	0
0	1	1	1
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Figure 4.43

4.4.10 For the 3-input truth table in Figure 4.43, use a K-map to derive a minimized product of sums (POS) logic expression.

4.4.11 For the 3-input truth table in Figure 4.44, use a K-map to derive a minimized sum of products (SOP) logic expression.

A	B	C	F
0	0	0	0
0	0	1	0
0	1	0	1
0	1	1	0
1	0	0	1
1	0	1	0
1	1	0	1
1	1	1	0

Figure 4.44

Figure 2 Example of Assessment Measures for Digital Logic Developed in this Project

2.3 Adaptive Learning Algorithm

Once a baseline of student understanding is measured, an adaptive learning system can be put into place as a supplementary instruction component to see its impact. In this work, the level of student ability is broken down into four levels (Deficient, Basic, Proficient, and Mastery). These correlates to a typical course grading scheme of Deficient=F/D, Basic=C, Proficient=B, and Mastery=A). The objective of the adaptive learning system is to make sure each student is at a level of proficient before moving onto the graded assessment for the outcome. The entire adaptive learning system is implemented using a formative assessment strategy so that the student's grade is not effective by missing problems with the system. The following figure shows the flowchart for the adaptive learning algorithm.

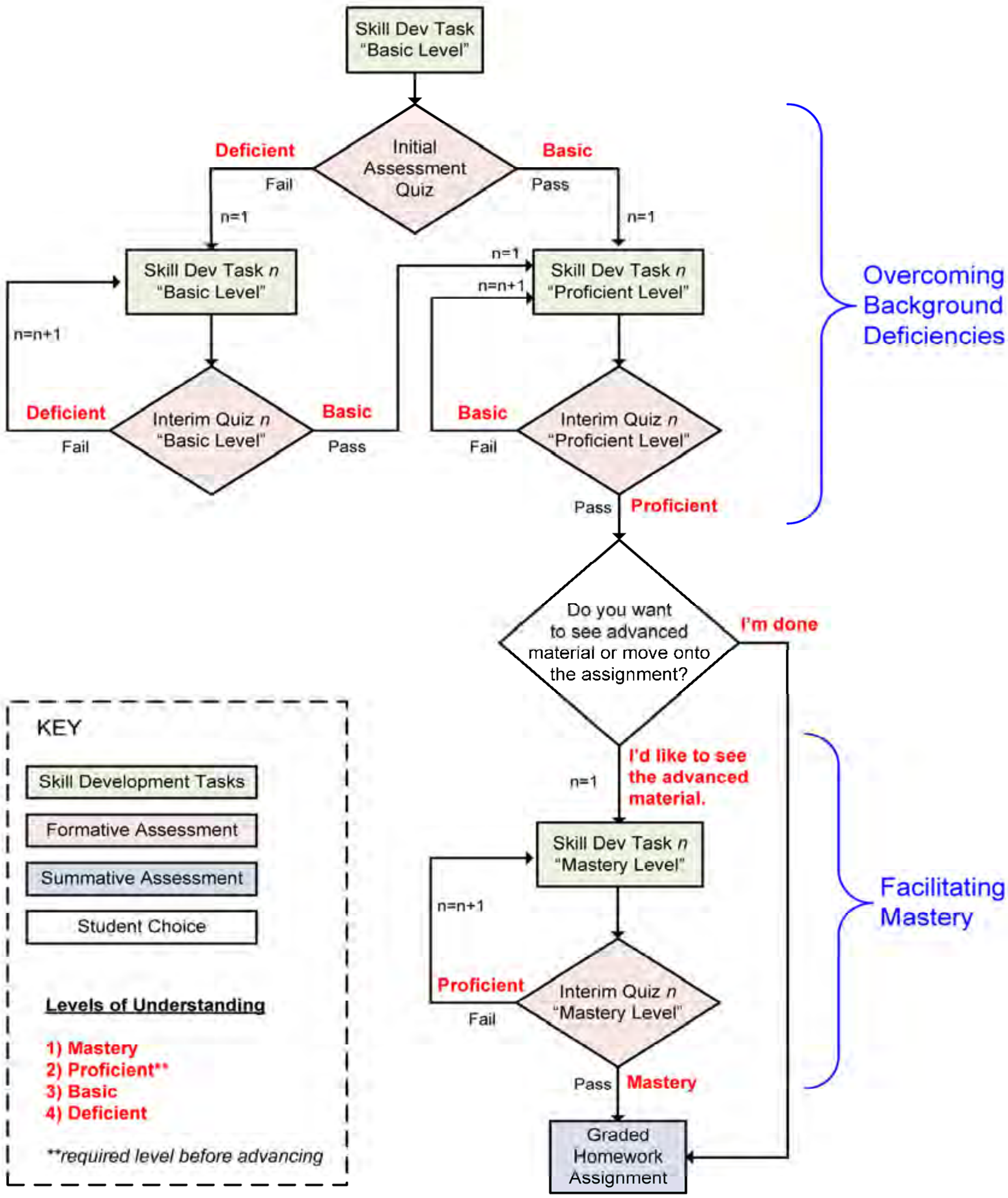

Figure 3 Adaptive Learning Algorithm Flowchart

After the student has performed all of the traditional learning activities for an outcome (i.e., reading, watching videos, viewing worked examples), an initial assessment quiz is given. The initial assessment determines whether the student is at a level of deficient or basic. Based on this assessment, skill development tasks are provided in the form of worked example videos and/or tutorials that highlight the key concepts of the outcome content. Each skill development task has the aim of preparing them to proceed to the next level by passing a subsequent assessment quiz.

Students move through the various levels (i.e., Deficient → Basic → Proficient → Mastery) by completing the skill development tasks and passing the next assessment quiz. The quizzes can be taken as many times as necessary and provide detailed feedback on each problem so that the quizzes themselves are integral to the learning. Each quiz pulls assessment tools from a test bank of questions with the appropriate level of difficulty. Students who reach the level of proficient are given the choice to proceed to the graded assignment for the outcome or participate in a Master-level skill development task. Students may opt out of the Master-level task at any time. Through continual formative assessment with detailed feedback, students are able to raise their level of understanding using this system.

2.4 Considering Student Demographics and Value Systems

One of the most key predictors of persistence is a student's experience of interest (Smith, 1999) as even highly competent students drop out of science and engineering majors citing "lack of interest" in the field (Seymour, 1997). One technique to increase interest is to use examples that the students are familiar with. This approach has shown great success in the Everyday Examples in Engineering (E^3s) program (Metz, 1999, Metz, 2011), in which problems are simply posed using material that the student body is familiar with as opposed to classical examples that don't relate to today's students. This approach doesn't change the content, or difficulty of the problem, it simply uses different examples that are more relevant to the students. As an example, consider the following example of how to calculate how long a battery will last.

Example 1. Calculating How Long a Battery Will Last	
Concept	• DC Power Consumption
Problem Statement	• A 9v battery is has a capacity of 500 mAh. If you are driving a circuit that consumes 20mW of power, how long will the battery last?

This problem is stated in the typical manner, but has little relevance to the student. A better way to pose the same problem is to use an application that the student is familiar with, such as a smart phone.

Example 2. Calculating How Long a Battery Will Last (2)	
Concept	• DC Power Consumption
Problem Statement	• Your smart phone consumes 1W of power. Its rechargeable battery has a capacity of 1000 mAh. If you charge your phone overnight and then disconnect it at 8am when you go to class, at what time will you run out of power?

Posing the problem in this way uses an example that each student is familiar with. Furthermore, this example is relevant to the students since each of them as had their phone run out of power at some point. Wording of the problem can also be used to stress other aspects of engineering, such as its contribution to public welfare and how it helps others. Consider the following example.

Example 3. Calculating How Long a Battery Will Last (3)	
Concept	• DC Power Consumption
Problem Statement	• A pacemaker consumes 1nW of power. Its battery has a capacity of 100mAh. How long will the pacemaker operate before it needs to be replaced?

This example stresses the communal value of engineering, which has been shown to be an important factor in the motivation of underrepresented groups, particularly women, to persist to graduation. Since this example may not be directly relevant to each student in the class, an adaptive system can target it toward those students with the demographics that tend to seek careers with communal value and that contribute to public welfare.

Notice that each of these three examples ask questions about the same concept. The only difference is the application that is used. The practicality of simultaneously using different forms of the same content is made possible by an adaptive e-learning system.

3. Results

3.1 Baseline Measures

Baseline data was collected at Montana State University over the course of 3 terms for the learning outcomes listed above. In order for demographic information to be collected, consent forms were signed by the students. With consent, the demographic information was pulled from university records and associated with each students' randomly assigned identification code. Figure 4 shows the students' performance on the 55 learning objectives developed in this work. At the top are the overall outcome average for the 200-level class, which covers modules 1-7, and the overall outcome average for the 300-level class, which covers modules 8-13. A vertical line is drawn at the edge of these averages to give a visual indicator of how each specific outcome score relates to the average. All scores were normalized to a 100% scale.

3.2 Pilot Study on Adaptive Learning

A small scale pilot study was conducted to see the impact of an adaptive learning module implemented for outcome 4.4 – Logic Minimization. This small scale study was implemented to verify the course management system (Desire2Learn) could implement the automatic assessment tools and competence level categorization. Figure 5 shows a snapshot of the adaptive learning environment used in the pilot study.

Of the 70 students that the adaptive learning system was offered to in the 200-level course, 60% chose to use the system. It is recognized that self-selection creates bias is the assessment of how much the modules helped learning, however, self-selection allowed the experiment to see whether certain groups chose to use the modules more than others. A variety of interesting results were discovered through this pilot-study. First, 16% of the students who chose to use the adaptive learning modules performed higher on the subsequent exam that covered the material in the modules as compared to their other exam scores that did not have adaptive learning modules available. Second, the students that chose to use the modules and benefited the most (as measured by their subsequent exam scores) had GPAs between 3.0-3.5. It was discovered that students with GPAs below 3.0 and above 3.5 were less likely to use the modules compared to students with GPAs between 3.0-3.5 and students with GPAs above 3.5 didn't see a noticeable improvement. There was an insufficient number of under-represented minorities in the pilot study to form any conclusions on the influence of gender or ethnicity. A survey was administered after the exam covering the material in the adaptive learning modules and 86% said they would use the modules to help them understand complex material if they were available throughout the course. While the sample size of this study was small, it did provide two findings that are further motivation for the proposed work. First, it is possible to develop and deploy an adaptive learning system using a standard course management system (e.g., Desire2Learn) and that the majority of the students desired more adaptive learning exercises.

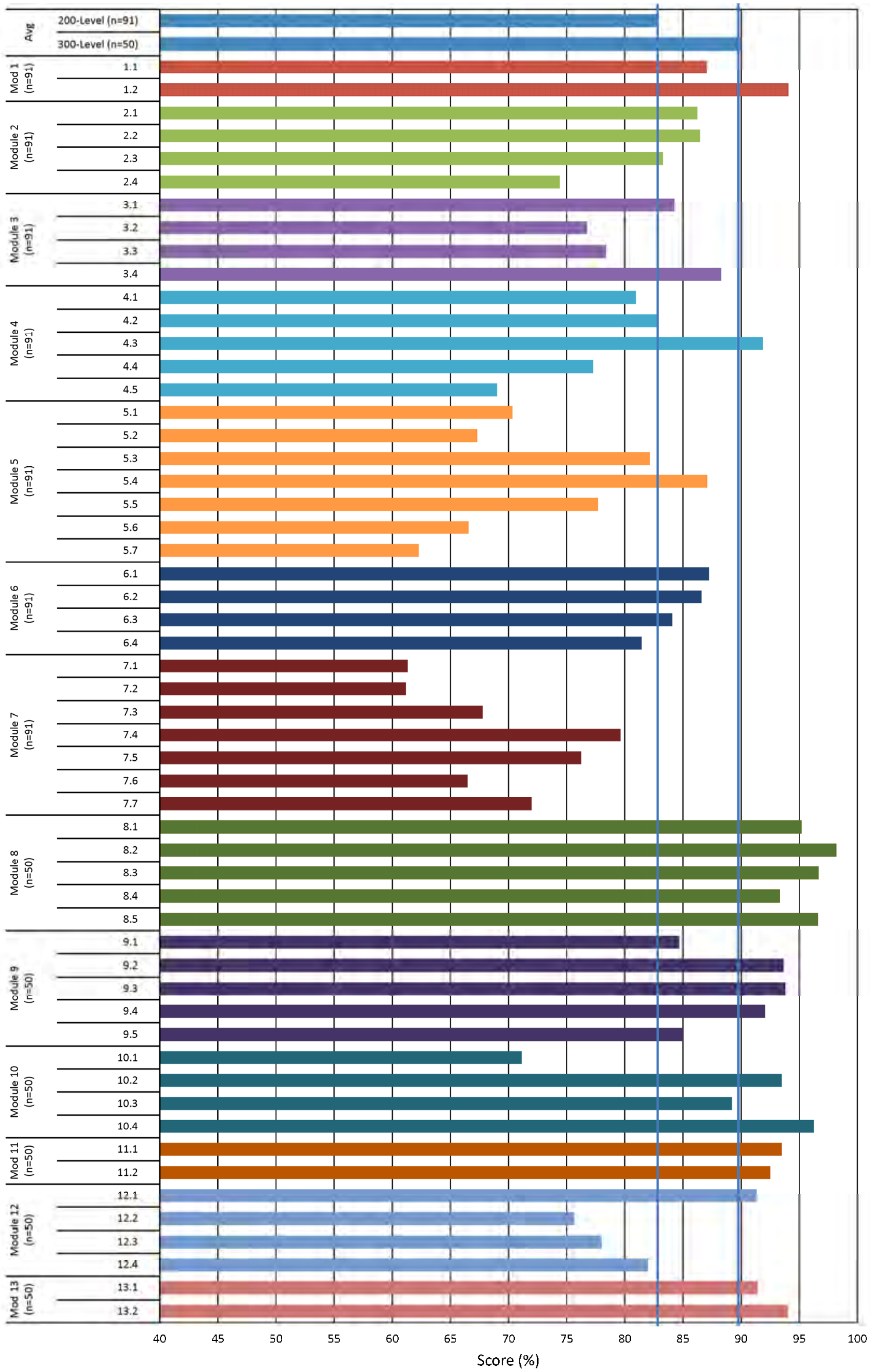

Figure 4 Baseline Understanding on the Learning Outcomes

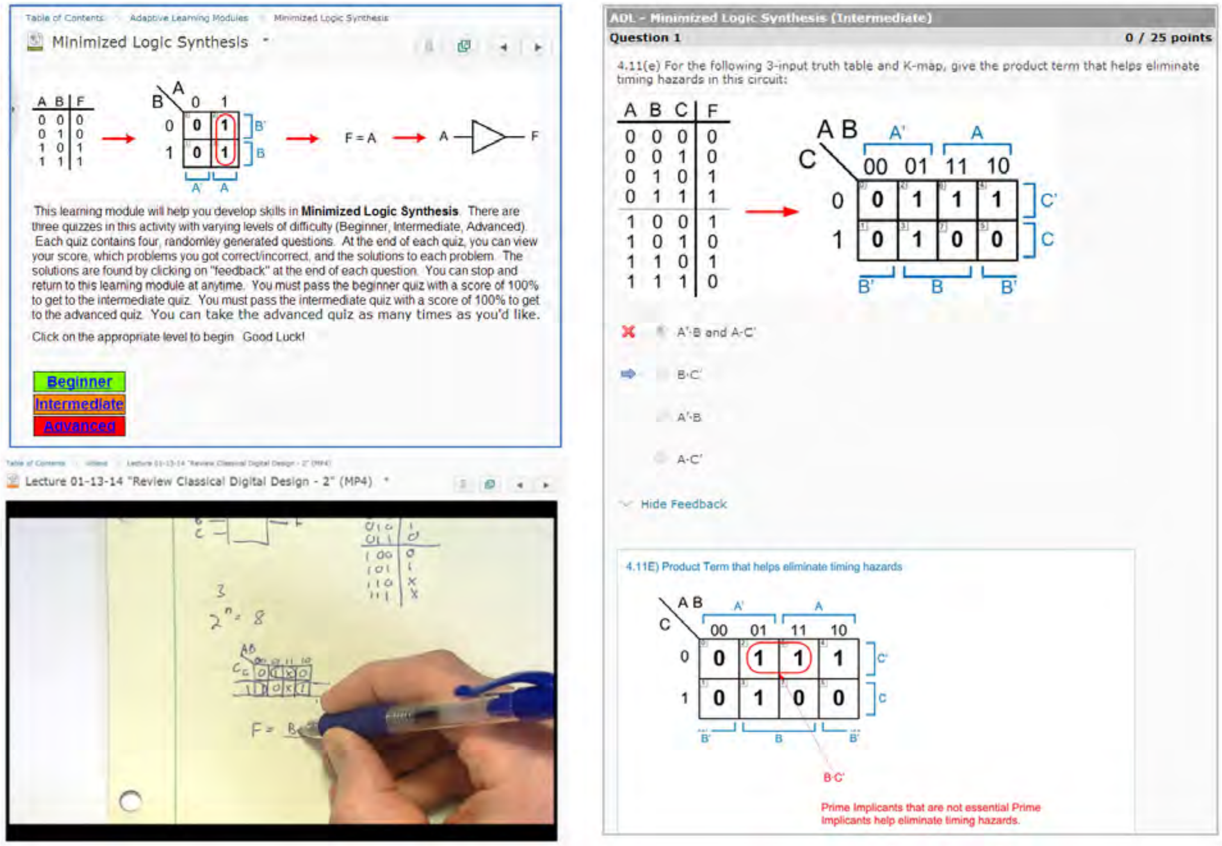

Figure 5 Snapshot of the Adaptive Learning Environment used in the Pilot Study

4. Current Status

4.1 Wide-Scale Deployment

Based on the results presented in this paper, an adaptive learning system has the ability to improve student learning and also be implemented using a standard course management system. We are currently developing adaptive learning modules for specific outcomes for deployment in the next academic term. The data collected will contain student demographics in order to determine if there are any confounding variables that highlight certain students benefit from the adaptive learning system more than others. Initial results are expected by the end of 2016.

4.2 Infusing Demo-graphic Specific Applications

Once the adaptive learning system is in place, we will be able to test interventions that change the wording and applications of the problems to target the interests of certain student demographics. Our initial focus will be improving the interest of female students. We will randomly assign the students into two groups. The first group will be the control group and will use the adaptive learning systems described in 4.1. The second group will have different applications that will highlight the communal value of the material, but will still measure performance on the learning outcome. A survey will then be administered to measure the motivation to persist in continuing in computer science and engineering is affected. Initial results are expected by the end of 2017.

5. Conclusion

This paper presented the development of an adaptive learning system that promises to address background deficiencies and facilitate mastery of introductory digital logic concepts. The system incrementally increases the level of difficulty of the learning material in order to guide the student learning. Through a continual formative assessment, students are able to improve their understanding of the material without consuming instructor time. This allows each student to reach the level of *proficient* before performing the graded assessment for each outcome. This paper presented 55 specific learning outcomes that match two courses commonly found in ABET accredited computer science and engineering curriculums. Each outcome had a corresponding learning category that mapped to a level within Bloom's Taxonomy for cognition. We presented baseline data on student understanding across these outcomes. The architecture of the adaptive learning system was presented in addition to the results of a pilot study on one outcome. The pilot study indicated that student performance on subsequent exams was improved with the largest gains being obtained by students with GPAs between 3.0 and 3.5. Our next steps include wide scale deployment and testing whether using applications of the material that have been shown to highlight the communal value of the content will improve the motivation of certain student groups, specifically underrepresented minorities and first generation college students, to persists in computer science and engineering curriculums.

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Virtual Presentation of Pressurized Water Reactor in Normal Operation and Accident Scenario Like the Fukushima as an Education Tool

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Abstract: This paper presents how the working principles and Fukushima-like accident scenario on a pressurized water reactor is visualized. A video is created to present the interior systems and event sequence during an accident caused by tsunami. The details of nuclear power plant operation under normal operation and an accident scenario are displayed. The video is shown with the illustration of the sequence of a nuclear accident similar to the Fukushima Accident in 2011, and introduction of passive systems as the follow-up actions. Reviewed on the Fukushima accident, features such as tsunami, break-down of diesel generators and partial core melt-down are demonstrated in the video. Following the accident scenario, passive systems are introduced as safety procedures which give an insight into how a reactor responses to an accident. Even for experts in nuclear engineering or on-site staff in a nuclear power plant, it is impossible for them to be physically present inside the system during normal operation or even accident. A virtual presentation can provide an easy and comprehensible way for the public to grasp the actual picture of a nuclear power plant. Especially after the Fukushima Accident, the safety of a nuclear power plant becomes a huge concern. It is important to illustrate the mentioned scenario to the public. This project combined the knowledge of nuclear engineering as well as creative media production.

Keywords: Nuclear engineering, engineering education, nuclear safety, severe nuclear accident, tsunami, station blackout

1. Introduction

In order to promote nuclear safety and nuclear power, it is important to educate the public on the basic. Nuclear accidents, especially the latest Fukushima accident, have raised public awareness of nuclear operation and its safety measures. In the light of limited accessibility to nuclear power information online, a reliable educational source for nuclear power is very much in need. However, nuclear power systems are complicated and it can be difficult for the public to understand with illustrations by words and simple graphics. Visual presentation can be an effective and interesting way to achieve the goal. Video is an excellent medium on education as it is comprehensive, flexible and interesting. They can also provide demonstrations and simulations which ideal for simulating a nuclear power plant environment. With an educational video of nuclear power plant operation, the public is able to understand and familiar with nuclear power plant. As a result, a video was created to demonstrate the working principles and an accident scenario on a pressurized water reactor (PWR). A 3-D model of a generic 3-loop PWR similar to CPR1000 is implemented in the video.

To complete the video, first of all, the working principle of a PWR is understood. Then, the review on the Fukushima Accident was conducted. The earthquake and tsunami caused a station blackout and led to inadequate core cooling for reactor 1, 2 and 3. Further review was conducted on the effect of a station blackout on a PWR. With the information gathered, animation was created accordingly and a video was produced.

1.1 Coolant System of PWR

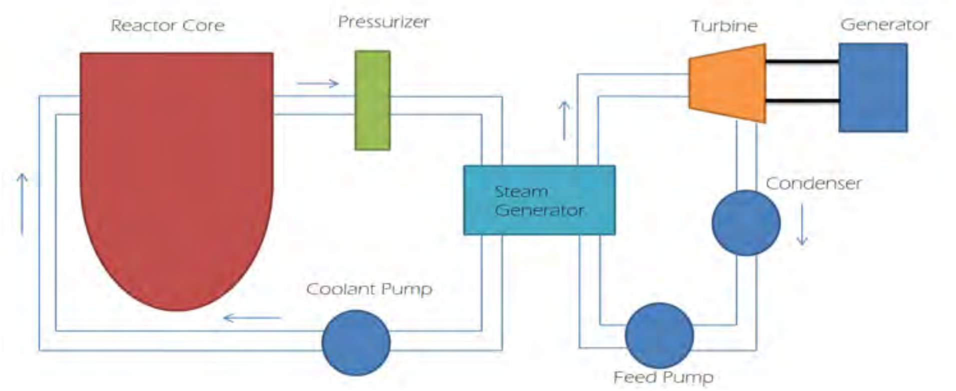

Fig. 1 Illustration of a PWR system

Pressurized water carries heat after passing through the reactor vessel and goes into the steam generator via the hot leg pipes. Heat exchange occurs at the steam generator. The water will then be pumped back to the reactor vessel by the reactor coolant pump via the cold leg pipes.

The heat exchange inside the steam generator will generate steam in the secondary loop which is separated from the primary loop. The generated steam carries on to the turbine for electricity generation. The secondary loop fluid will be cooled by the main condenser and return to the steam generator.

1.2 Fukushima Accident

On 11 March 2011, triggered by a severe earthquake, followed by a 15-metre tsunami flooding in the northeast coast of Japan where Fukushima Daiichi reactors located, causing tremendous damages and severe nuclear accident.

There were a total of six boiling water reactors at the Fukushima Daiichi site. 3 out of 6 of them were operating at full power. The other 3 were shut down for refueling. Unit -1-3, which were the operating units, was shut down when sensors at the nuclear power plant detected the earthquake.

During shut down, unit 1-3 continued to produce decay heat. Decay heat had to be removed to prevent core damage. The heat removal was supposed to be removed by cooling systems. However, the earthquake itself damaged on-site switch yard equipment, off-site substation equipment, and the AC power lines. The following tsunami overwhelmed the flood wall and damaged the backup diesel generators. AC power was completely lost for unit 1-5, leading to a station blackout accident scenario.

The cores of the three Fukushima Daiichi reactors largely melted in the first three days after the tsunami. Fukushima accident has been graded as level 7 in INES (The International Nuclear and Radiological Event Scale) scale, which is the highest level, indicating the serious damage caused by the event.

The Daiichi plant was not designed to withstand tsunami. Referring to the official licensing documents, the design basis tsunami of Fukushima Daiichi was estimated to be 3.1 m at maximum above the sea level. Based on this estimation, the company decided to situate the seawater intake buildings 4 m above the sea level while the main plant was located on the top of a slope which was 10 m above the sea level. For the Daini plant, the plant was built 13 m above sea level. The 2011 tsunami hit the shore with 15 m high which fully covered the Daiichi turbine halls. The Daini plant was less affected when the tsunami came ashore.

Normally, in the cooling system of the reactor core, the circulation of water is achieved through high pressure systems cycling water between the reactor pressure vessel and the turbine. The secondary cycle uses a separate water supply to provide cooling for the primary coolant in the condenser. The seawater pumps, a part of the residual heat removal cooling system, mainly used for both the main condenser circuits and the auxiliary cooling circuits were inundated and damaged by the tsunami. Diesel generators, electrical switchgear and batteries, which were stored in the basements of the turbine buildings, were drowned and incapable to function. Therefore, there was a station blackout and the reactors were isolated from the ultimate heat sink. Without instrumentation and control, the batteries could not provide electricity for efficiently running the cooling system.

Without proper cooling, the core suffered from extremely high temperature. Fuel rods were overheated as the residual heat accumulated and failed to be delivered away since the backup diesel generators were ruined during the tsunami. Fuel rods melt down and the molten fuel “corium” damaged the Reactor Pressure Vessel and penetrated through the vessel to the bottom of the Primary Containment Vessel (PCV) with associated radioactive materials. The progress was stopped by the concrete of the PCV.

The accident was mainly down to the flood-prone location and the failure of emergency diesel generators which led the core meltdown. Loss of coolant accident (LOCA) was the major cause to the accident and had triggered severe events such as reactor core meltdown and the hydrogen explosion leading to the exposure of radioactive materials to the surroundings. Failure of emergency diesel generators leading to loss of coolant accident and core meltdown is selected to be the main features in our project.

1.3 Station Blackout on PWR

Similar to Fukushima Accident, the accident scenario for the video is a station blackout accident. Instead, the situation is focused on a PWR.

After the loss of AC power, the core will still receive core cooling from the initial core coolant inventory. The primary loop pressure starts to increase and reaches the pressure safety valve set point. The water level in the reactor vessel will decrease due to the loss of coolant inventory through the pressure safety valve. The core starts to be uncovered. At the meantime, water level of steam generator decreases. The uncovered fuel then starts to heat up due to the lack of coolant. The core eventually starts to melt. Molten core will then relocates at the bottom of core, forming a corium.

Loss of Coolant Accident may occur at the same time and further decrease primary loop’s coolant inventory. According to Prošek and Cizelj (2013), leakage of reactor cooling system fluid through seals would occur without make capability which may eventually lead to core uncovering. Vierow (2004) also stated that the steam produced by core decay heat and metal-water reaction during this period is hot enough to challenge the integrity of primary loop boundary heat structures, such as steam generator tubes, pressurizer surge line and hot legs. In the station blackout scenario, this cause a risk of failure at the primary loop boundary heat structures before the reactor vessel lower head breach. This indicates that there could be a release of primary loop coolant to the containment before

the vessel melts.
If no measures can be taken to resume core cooling, the vessel will eventually fail. At this stage, as the primary loop still remains at a relatively high pressure comparing to the containment, a high pressure melt ejection will occur. Molten core will be ejected out of the ruptured vessel.
According to Hong Kong Nuclear Investment Co. Limited, there are a few back-up cooling system available for core cooling. They are available during shutdown or primary leakage.

1. Accumulator
2. Boron Injection Tank
3. Gravity Driven Water Tank

During the beginning of the accident, the primary loop and secondary loop should continue to flow for a short period of time. When the water level of steam generator start to decrease the turbine driven auxiliary feedwater able to provide water for steam generator. The turbine driven pump is run by the steam flow in secondary loop and the beginning of event.

There are 2 water sources that do not require electricity to provide core cooling. They are the accumulators and the gravity driven water tank. Accumulators are connected to the primary loop which water pressurized with nitrogen gas. Once the primary loop pressure falls below the nitrogen pressure, the gas will push out the water inside the tank to provide core cooling. For the gravity driven tank, it is located at a relatively upper level comparing to the reactor. As a result, water inside the tank can be driven by the potential difference.

2. Video Production

After obtaining sufficient information about normal operations, station blackout accident on Pressurized water Reactor and available safety systems on the previous section, visualizing the whole scenario will be the next step.

An overall workflow is developed for the production of the video.

1. Develop the 3-D model, effect addition to complete the scenario
2. Record the completed scenario
3. Simple editing, narration

2.1. Normal operation mode in the video

As the water flowing inside the reactor is different in temperature, colours of yellow and red are used to represent the temperature difference. The core vessel has six pipes linking with the three surrounding steam generators which are presented in black and white. During the normal operation in closed system, the core is filled with water and condensed steam. Blue transparent cylinder is set inside the core vessel for manifesting the volume capacity. Apart from it, fuel assemblies of metallic texture are centred in the core. As the reactor operates normally, the cooled water flows into the core through cold leg pipes to take away heat from the core whereas the heated water is flowing towards the steam generator via hot leg pipes for heat exchange.

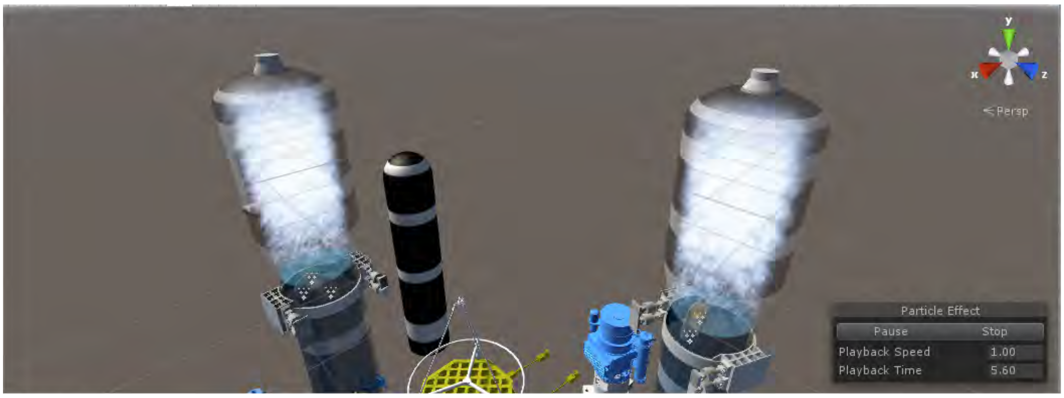

Fig. 2 Simulating steam in steam generator with Unity

Inside the steam generators, heat exchange takes place as the heated water from the hot leg flows into the generator in separated pipes. The U-shaped pipes are designed for effective heat exchange in the reactor operation. Coolant water is fully filled within the generator and separated from the heated water from the hot leg pipes. The heated water flows up at the beginning in the U-shaped tube and heat exchange happens. The extreme temperature difference aids the heat transfer which generates steam. After the process, large amount of steam is formed and becomes saturated as it is confined to the steam generators which are of high pressure and temperature. The condensed steam is then delivered to steam dryer for moisture removal before passing through the turbines. The condensed steam stays on top of the U-tube and confined to the generator. The cooled water flows downwards in the U-shaped tube and directed back to the core for cooling after the heat exchange in steam generator.

2.2 Accident mode in the video

Since the video is based on Fukushima accident in Japan, a few important features causing the disaster has been extracted and shown in the video. First of all, the occurrence of the breaking down of diesel generators leads to malfunction in delivering coolant water into the reactor core. According to Fukushima accident, the diesel generators were built 4 m above the sea-level. However, the strong tsunami, which measured to be of height of 15m, struck the building where diesel generators were located. A scene of diesel generators being drowned included for explanation. In an attempt to show the malfunction of the generators after being covered by rising seawater, a cube has been used to illustrate the rising water level inside the block in which the generators are set. For the simulation of tsunami, default water planes are used and designed with high amplitude and frequency. After the rising water fills the block, sparks and flare exist to indicate the damage of the generators. In order to present the water flooding into the block where the emergency diesel generators located, a cube with animated effects and colour is set inside the block. Movement of increasing water level will be shown after the hit of tsunami. Due to disconnection with electricity, the seawater pump activated by power fails to pump in the seawater for cooling inside the reactor. Therefore, there is no sign of water flow in the seawater pump after the break-down.

The final scene is to show the following accident that takes place after malfunction in diesel generators. The water flows into and out of the core through either pipes are shown in red colour for indicating that it is of extremely high temperature. The core is illustrated by bright yellow rods as to resemble the actual melting state of metal. It is worth noted that the water level inside the core falls slowly due to the change of states of heated water. In addition, the core is shown with different colours from yellow to red in order to demonstrate the extreme temperature changes. Referring to the basic physics regarding the core water, much of the heated water is converted to steam owe to the abnormally high temperature condition in the core. As much of the liquid water turns to vapour, small amount of water left in liquid form in the core.

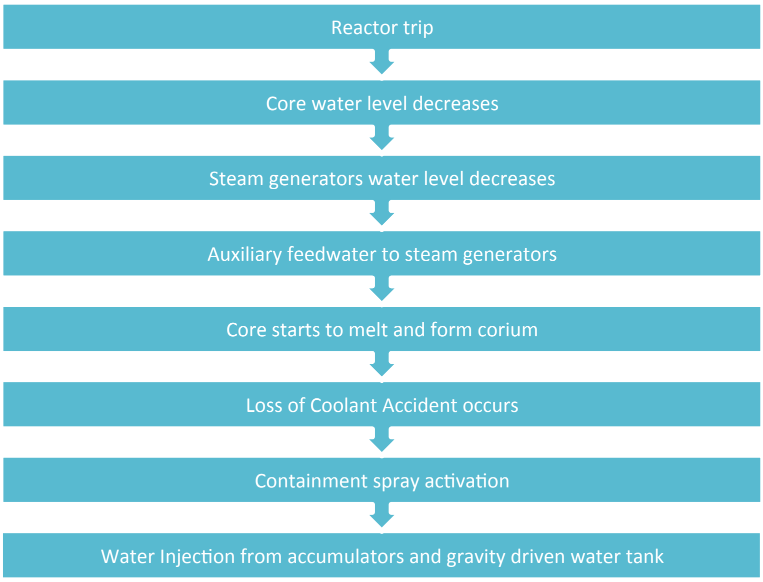

Fig. 3 Event sequence of accident scenario

An event sequence is made to be referenced during the production. According to the literature review on the accident and available safety systems, the sequence should be as follow after the loss of AC power.

A 3-D model of a generic 3-loop PWR was developed within the Unity Game Engine.

The first step is to complete the first loop of reactor. Piping is drawn with Autodesk 3ds Max.

Fig. 4 3-D model of completed first loop in Unity

Others essential components such as water in core, fuel assemblies and control rods were modelled as well in Unity. With the completion of the first loop, effects were then added according to the event sequence developed to complete the video.

2 major functions in Unity were used. They were the Particle System function and the Animation

function built in Unity. As there are coolant flows within the first loop, different Particle Systems were developed to represent different flow. For example, the normal coolant flow in first loop and emergency coolant flow from water tanks.
Particle System function provides a wide range of modification tools such as emission colour, force over lifetime, rotation over lifetime etc. This allows easy modification and representation of different coolant flow in the video.

The animation function was applied on modelling water level decrease, reactor trip as well as camera movement. Different keys are set to modify the properties of a game object such as scale rotation, position etc. to create the desired animation.

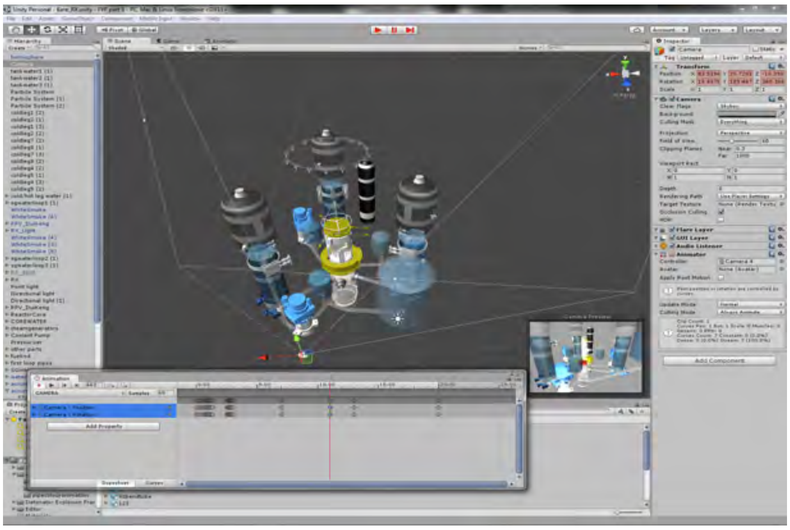

Fig. 5 Animation function in Unity

The video is then recorded with Open Broadcaster Software Studio after the game scene was built and further edited in Windows Movie Maker.

3. Conclusion

An animation with all details and accident sequences has been completed with the use of different software. However, since the illustration is in the form of animation with selected features shown, it may not provide a comprehensive coverage of nuclear operation which involves other complicated elements. The video is a simplified version of nuclear operation which captures the most essential parts during different conditions for explanations. As the video is mainly developed for the public, it is appropriate to include the most crucial features.

4. Future Works

The video may require adjustments. Some parts of the video may not reflect the actual situation completely and they will be discussed in the following. The shape of steam in the steam generators may not mirror the actual case in the video. For the convenience of making details of the reactor core, several components are converted to be transparent which leads tiny components missing and seemed abnormal.

In the light of the limited nuclear knowledge of the public, organizations that involves in nuclear industries may consider to convey accurate information to the public through various means. Information of nuclear power plant designs and its safety systems are of paramount importance. This helps to boost the confidence of the public towards nuclear power and promote the development of nuclear power in the nearer future.

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Blended Learning in Engineering Education: Students' and Lecturers' Perceptions and Achieving Learning Outcomes

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Abstract: In recent years the focus of university education is shifting from a teacher centred education to student centred learning. This shift is mainly due to the availability of enormous amount of educational software and the competency in computer technology of students entering universities. Also the demand for flexible learning environments is increasing because many university students nowadays work part-time or full-time while studying due to societal changes attributing to their lifestyle. In this paper Blended learning initiatives put forward by the Western Sydney University for engineering units are discussed emphasising students' and lecturers' perceptions on blended learning. One aim of this initiative is to give a flexibility learning environment for students, who may not be able to attend lectures regularly due to work commitments, utilising the technology in terms of recorded lectures and tutorials. Based on the feedback from students and lecturers, this research investigates how far we can move away from traditional face to face teacher centred education, while meeting professional competencies set out by Engineers Australia and achieving unit learning outcomes.

Keywords: Blended learning, Engineering education, Learning outcomes, online delivery, professional competencies

1. Introduction

The advances in Internet and Wireless technologies as well as convenience in accessing them at any place whenever necessary in recent years is enabling the younger generation of school leavers to be extremely versatile with computer use and internet technologies. As a result, universities around the world are striving to make courses more interesting, attractive and flexible for this tech savvy new generation by introducing computer based e-learning technologies. As a result, the term Blended learning, has emerged in the higher education realm.

The definition of Blended learning is the integration of computer technologies effectively to enhance the teaching and learning experience of both lecturers and students. Literature about Blended learning applications in higher education shows the benefits of e-learning integration in tertiary courses (e.g., Abraham, 2007; El-Mowafy et al., 2013; Gonzalez et al., 2013, Ekwunife-Orakwue and Teng, 2014, Wardenski et al., 2012) but some researchers pointed out weaknesses in Blended learning (e.g. Sethy, 2008; Ellis and Calvo, 2004). However, benefits of these new educational strategies to teaching and learning should be affirmed cautiously and implementation should be carried out after broader discussions of the context of applications and also the expectations of students (Wardenski et al., 2012).

According to Debnath (2014), higher education community regards online courses with some uncertainty. This may be a result of lack of institutional culture and knowledge (Wardenski et al., 2012) as well as mixed results found in the literature from case studies. Another reason is that the lecturers are not familiar with the practices of creating and delivering same courses they learned as students and delivered for years in face to face settings through virtual learning environments (Porumb et al., 2013). Especially for engineering education, lecturers still do not consider the e-learning methodologies are stable enough and powerful for delivering courses integrated with practice oriented activities such as laboratory experiments and group design projects. Nevertheless integration of computer based technology in tertiary education has been considered as a promising approach to combine with face to face teaching and growing rapidly in Australia and it is predicted to become the new traditional model in university education (Graham 2004), though it is still at its preliminary stages of exploration.

According to Twigg (2003), there are five Blended learning models: (1) Supplemental model, (2) Replacement model, (3) Emporium model, (4) Fully online model and (5) Buffet model. In the supplemental model, the traditional face-to-face course structure and class meeting times are retained and out of class activities are introduced to enhance student learning. In the Replacement model, class meeting time is reduced and the face-to-face time is replaced by on-line activities for which students can participate from anywhere at any time. As discussed by Twigg, the Emporium model is different to other models because it replaces all class meetings with a learning resource centre using online materials and on-demand personalised assistance. In the Buffet model, the teaching approach used is different to other methods. Other four models are cost effective and the students were considered as the same, in other words all students complete the courses with the same assessments and learning resources. In the Buffet model, learning is customised based on the needs of the students (Twigg, 2003). Depending on the choice and strength of individual students, they will enter a learning contract at the beginning, selecting their preferred options. They receive an initial orientation and during the term progress is tracked.

Each blended learning model discussed above has its own merits and demerits, within the delivery of engineering education. The fully online model is not suitable due to requirements of hands on laboratories and computer software tutorials, where software licenses can be used only in university computers. Hence, class meetings cannot be completely eliminated and other four methods can be considered as suitable blended learning models for engineering education. However, the Blended learning models currently in place for engineering education can be categorised under Supplemental and Replacement models.

A Blended learning model is introduced at the Western Sydney University (WSU) in 2013 within the undergraduate (BEng) and postgraduate (MEng) engineering courses via the e-learning system. This paper will investigate the students' and lecturers' perceptions of the Blended learning model adopted at WSU and how this model has affected the student learning and achievement of professional competencies set out by the Engineers Australia.

2. Blended learning model used at WSU

The blended learning model introduced at WSU engineering units in 2013 is more aligned with the Supplemental model, however the university aims to move towards a Replacement model, due to the multi-campus offerings planned for Engineering (both undergraduate and postgraduate levels) starting from 2017. Currently in majority of undergraduate units, lectures were recorded and posted in the e-learning system known as 'views', few hours after the lecture. The system, which records lectures automatically in many lecture theatres and posts in views, is called the 'lectures online'. In some units, face to face delivery was partially replaced by recorded lectures and tutorials. Tutorial recordings were not made during the normal class meeting times. They were recorded manually outside the scheduled tutorial class meeting time. In some units, online quizzes, online assessment submissions, online feedback on assessments, recorded laboratory experiments and discussion boards were also facilitated through the e-learning system.

After the introduction of blended learning, a significant decline in class attendance of students was observed. For example, if about 80% of students enrolled in a unit attended lectures before university introduced lectures online, it was reduced to about 25% of attendance for many units after introduction of Blended learning. This decline in student participation and concerns regarding students' achieving learning outcomes and professional competencies set out by Engineers Australia, such as team membership, leadership skills and communication, are the motivation for this research. Research was carried out using survey data collected from both students and lecturers as outlined in the following sections.

3. Survey for Students

The survey issued for students consists of only eight short answer questions to get a genuine response from students. Some students may not complete the survey, if a large number of questions were included. The length of questions were also kept short and used simple questions requiring either 'Yes' or 'No' as the answer and descriptive questions were included requiring them to demonstrate the reason for selecting either 'Yes' or 'No' as their answer. In this study, the survey delivered to students aimed to get feedback on student perceptions about three areas: (i) face to face teaching, (ii) Lectures Online and (ii) Flexible learning, as shown in Table 1.

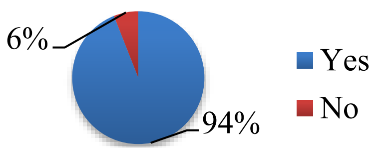
The survey forms were distributed to students and they were given the freedom to complete and return anonymously. Out of all the distributed forms only 92 surveys were returned. From first and second years 49 students and from third and fourth years 43 students consist of this group. In this section results are presented from the composite group of first to fourth years but results were analysed for the first to second years and third to fourth years in two separate groups. The idea was to investigate whether the junior and senior level undergraduate students have the same understanding on the face to face teaching, lectures online and flexible learning. When discussing these results, it is important to keep in mind that the surveys were issued to students who attended the lectures. Since the attendance drastically reduced after lectures online introduced, the sample size of this survey is small and another reason is it is issued towards the end of the semester in week 10 when student attendance is typically low.

According to the data collected in this survey, as shown in Figure 1(a), 94% of the student cohort agreed that the face to face teaching is the most useful mode of delivery. The common reason given by those who answered 'Yes' is the opportunity students get in asking questions in real time, when they have issues in understanding the concepts. Also students appreciated the opportunity they get to engage with their peers during the lectures. Students liked the study environment within the lecture theatre and accepted it as a more conducive environment to learn, rather than studying in isolation in front of a computer. Those who answered 'No' to question one, the main reason is specifically about the lecturer. They gave the reason as the communication problems of the lecturer. However the number of students who do not agree with the fact that face to face learning is better than other teaching modes is a very small percentage of 6%. Based on these results, it is a question whether a Blended learning model, which reduce the face to face teaching, is the best solution even though it is obviously the most economical approach due to ability in repeatability of lectures in a multi campus setting.

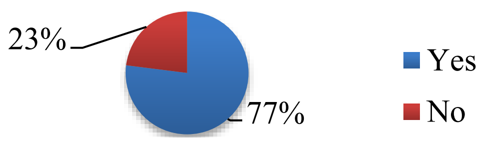
Next section of the questionnaire is about the students' perceptions related to lectures online introduced by WSU as part of the Blended learning initiative. As shown in Figure 1(b), only 77% of students said they watched lectures online weekly. However, as shown in Figure 1(c), 88% of students agreed that they are a useful resource for their learning, which is a larger proportion compared to the 77% of students who watched lectures online in a weekly basis. The reasons they gave for answering ‘Yes’ to this question are: (i) by watching the lectures online they could revise what their lecturer taught in class and (ii) if they miss the lecture, it is a good source to revise the material. Those who mentioned that the lectures online is not a useful resource mentioned that they selected that answer because (i) they preferred face to face teaching to e-learning, (ii) they like the learning environment and (iii) it allowed them to interact with both peers and lecturers.

Table 1. Survey distributed to students.

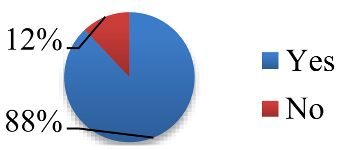
<table>
<tr><th colspan="2">Face-to-Face teaching</th></tr>
<tr><td colspan="2">1. Do you think face-to-face teaching is valuable in comparison to other modes of teaching?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td colspan="2">2. Please explain the reasons for selecting the above answer.</td></tr>
<tr><th colspan="2">Lectures Online</th></tr>
<tr><td colspan="2">3. Do you access lectures online in views weekly?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td colspan="2">4. Do you see any value of lectures online?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td colspan="2">5. Please explain the reasons for selecting the above answer.</td></tr>
<tr><td colspan="2">6. Because of lectures online, do you think that your attendance to face-to-face lectures reduced?</td></tr>
<tr><td>Yes</td><td>No</td></tr>
<tr><td colspan="2">7. If you selected "Yes" to the above question, how do you think this affected your learning?</td></tr>
<tr><th colspan="2">Flexible Learning</th></tr>
<tr><td colspan="2">8. What is your perception of flexible learning?</td></tr>
</table>



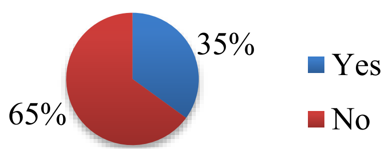
(a) Face to face teaching is useful in comparison to other models (Q1)



(b) Access lectures online weekly in views (Q3)



(c) Lectures online is useful (Q4)



(d) Lectures online reduced attendance to Face to face teaching (Q6)

Figure 1. Summary of quantitative questions in the survey given in Table 1.

Figure 1(d) shows the response to the question, whether lectures online has reduced their attendance to weekly face to face lectures. For this question, only 35% answered ‘Yes’. From this group, 65% said lectures online has not reduced their attendance. Students who mentioned that their attendance reduced mainly due to the travelling distance from the home to university. Also they mentioned that lectures online is a much better option for students who fall behind because they can repeatedly watch the online lecture if they cannot understand any concepts. Few students enjoyed the fact that they do not need to attend the lectures because all information is on lectures online. Those who said their attendance has not reduced due to lectures online mentioned reasons as they liked the interaction with others within the lecture room and it gave them motivation to study when they see peers studying.

The last question of the survey is about the students' understanding of the flexible learning. This is also important within the context of Blended learning because one of the ultimate goals is to provide a flexible environment for our students. Students who appreciated flexible learning said it is good when they have other commitments because the class attendance is not rigid as in a traditional face to face setting. Also they said flexible learning makes them to maintain a good life balance between study commitments and free time. Some students said flexible learning is not good because it will reduce class attendance and makes them less interested towards learning, lessening their exam performance.

The main conclusion from this part of the study is that although a large proportion of students see the benefits of lectures online, they do not like to reduce the face to face class meeting times. Therefore, based on the Blended learning models discussed earlier, supplemental model is the one preferred by undergraduate students. However, for cost reduction and providing a flexible learning environment, Replacement model is more preferable. In that case, a right proportion of e-learning and traditional face to face learning should be used. This proportion is not a uniform value across a discipline and may depend on the academic abilities of the student cohort as well as the degree of difficulty of the unit. Blended learning model with lectures online and reduced class meeting times can be a weakness for students who do not have the right motivation to engage actively in learning. Another important conclusion from this study is that the two separate groups of junior and senior undergraduate students analysed show that this conclusion is consistent between both groups.

4. Survey for Staff

This section of the paper examines the survey conducted for engineering academic staff. Only 17 lecturers returned the completed questionnaire shown in Table 2. This is also an anonymous survey similar to the student survey. The questions were mainly categorised under four main areas: (i) face to face teaching, (ii) Lectures online, (iii) Flexible learning and (iv) Blended learning.

Figure 2 shows the summary of results for the quantitative questions in the questionnaire. For question 1, all participants selected 'Yes' to indicate that the face to face teaching is valuable in comparison to other modes of teaching. According to the staff, face to face teaching provides mentoring for students during teaching. It is an interactive mode of teaching and students will be able to get instant feedback for their questions and hence problems will not accumulate till closer to the exams. In a classroom setting, it is not like when you listen to a lecture at your home in front of a computer. Students are able to focus on the lecture without external distractions. It will provide an environment for social interactions and discussions in which they develop ideas and create knowledge beyond the content in the lecture slides because lectures online capture only the content in the slides. If the lecturer explains any extra details on the whiteboard, lectures online will not include that content. When students are among their peers, it gives an incentive towards learning and meeting deadlines. Also lecturers will be able to understand student progress while teaching a certain topic. Some staff members mentioned that the active learning should be promoted through more face to face tutorial classes and using Flip mode of delivery if the face to face lectures are partially replaced by the recorded content. In the Flip mode, students learn the subject matter outside the class listening to a pre-recorded lecture and then come for a supervised tutorial class to work on problems.

Currently 88% of lecturers recorded all their lectures, as shown in Figure 2 (a), and they were made available to students in the e-learning system, views, after the lecture. However, according to Figure 2(b), 88% of lecturers consider that lectures online is not beneficial to their students. The main reasons for selecting this answer given for Question 5 was that they thought lectures online discourages attendance to lectures. Many students, who do not attend lectures, wait until the exam time to learn the unit content via lectures online, which is not progressive learning.

According to the staff survey, a number of lecturers monitored student participation in lectures online using the statistical tracking activated in views. They observed that the number of students accessing lectures online normally increased during the last two to three weeks of the semester. During the rest of the semester, less than 1% of students viewed lectures online for some units. Another serious issue is lectures were recorded by the university IT services and lecturers do not have any control over the quality of recordings. If the quality of the recordings were bad, student evaluations on teaching (SFT) and unit evaluations for unit (SFU) scores were suffered because students directly put the blame on the lecturer. Overall all staff said students do not interact with others and they get a very narrow view of the unit by not attending the face to face lectures.

Table 2. Survey distributed to academic staff

Face-to-Face Lecturing	
1. Do you think face-to-face learning is valuable in comparison to other modes of learning?	
Yes	No
2. Please explain the reason for selecting the above answer	
Lectures Online	
3. Do you provide lectures online in vWUS?	
Yes	No
4. Do you think that your students take the full benefit of lectures online?	
Yes	No
5. Please explain the reasons for selecting the above answer	
6. Because of lectures online, do you think that student attendance to face-to-face lectures reduced?	
Yes	No
7. If you answered "yes" to the above question, how do you think this affect the learning of your students?	
Flexible Learning	
8. What is your opinion on the “flexible learning environment”?	
Blended Learning	
9.What is your perception on blended learning in terms of student performance in your unit and interaction between lecturers-students as well as students-students?	
10. Apart from recorded lectures, what other blended learning approaches have been implemented in your units?	
11. Do you think new blended learning approaches introduced at UWS will effect achieving the professional competency levels set out by Engineers Australia (e.g., team membership and leadership skills, communication, team design projects)?	
12. In what ways the blended learning influenced the average assessment marks in your units?	

As illustrated in Figure 2(c), 76% of lecturers identified that the attendance to lectures has drastically reduced after the introduction of lectures online. When students do not attend lectures and attempt to learn by watching the recorded lectures, they cannot participate in stimulating discussions, which occur in a traditional class setting and become a silent audience. As a result their critical thinking ability will degrade and they wait till the last few weeks of the semester to study for the exams. Again if they do not watch the videos, they have to rely on a set of slides with minimum information. On the other hand individual student consultation times will increase because in the classroom all students will hear the questions and answers but when students study individually, many students come to the lecturer with similar questions increasing the individual student consultation times.

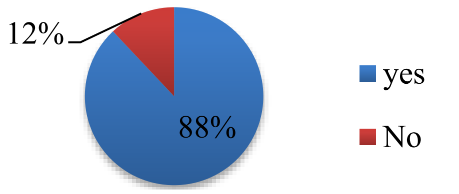
As given in question 8 (Table 2), the same question about the flexible teaching environment was asked from the lecturers. Majority of staff said flexible learning is good only for motivated students. It will give time for part-time working students but the convenience brought to the teaching and learning will be a failure for some students due to procrastination. Some lecturers suggested to introduce a minimum requirement for participation and setting thresholds to pass the main assessment tasks including the final exam. Then students must complete main assessments to meet the threshold criteria, instead of selecting only few assessment tasks to do well, which carry a higher weight towards the final mark.

The last section of the staff survey was devoted to Blended learning. It is important for both lecturers and students to have a clear idea of the blended learning and how this should be implemented in teaching without downgrading our course standards and student learning outcomes. In this question lecturers' perception on Blended learning was asked in terms of Lecturer-student, student-student interaction and student performance in units. Majority of lecturers identified that the students do not have the correct view of Blended learning related e-learning initiatives and as a result they think that they do not need to attend the lectures, if lectures are recorded. For mature and motivated students, e-learning will not effect the performance as they use e-learning as a supplement to face to face teaching rather than a replacement. Also it reduces the opportunities for group assignments, which is a mode of learning involving students in a group motivating each other. Hence, some lecturers suggested that the exam performance of students will degrade due to blended learning.

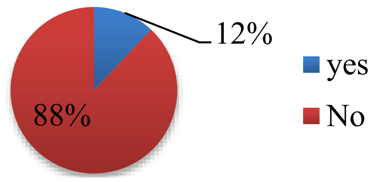
Currently engineering academic staff use a variety of e-learning resources in the e-learning system views and they consist of links for resources available in the internet, online quizzes, pre-recorded videos for labs, discussion forums, collaborate sessions, recorded tutes, videos from text book authors, video solutions for tutorials, in addition to the recorded lectures. All units do not have all these resources but all units have recorded lectures if the classroom has recording facilities. However, it is clear that students do not get the maximum use of these resources to enhance their learning.

In question 11, it was asked whether lecturers think new Blended learning approaches introduced at WSU will effect achieving the professional competency levels set out by Engineers Australia (e.g., team membership and leadership skills, communication skills, and team design projects). All staff stated that achieving above mentioned professional competencies are an issue, when students are not interacting with peers. They do not master the skills necessary for teamwork or building relationships with peers or communication skills. Also in units with group design projects, students constantly approached unit coordinators claiming that they cannot form groups because they do not know others enrolled in the unit.

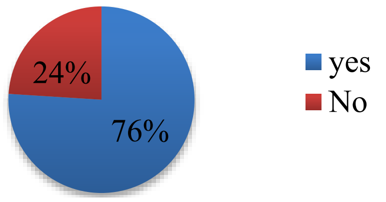
The response given for the last question is summarised in Figure 2(d). It is clear that a significant proportion of lecturers' view is that the Blended learning has affected the student performance in their units. According to the answers provided by lecturers, some units with high mathematics based content, failure rate has doubled. According to this response e-learning may not be a successful mode in engineering units with high computational volume. However, for descriptive units related to humanities or management, which involves less critical thinking and problem solving skills, e-learning methods can be used to reduce the face to face teaching.



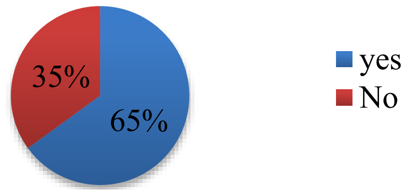
(a) Lectures were recorded and posted in blackboard (Q3)



(b) Students take advantage of lectures online (Q4)



(c) Attendace to face to face lectures reduced (Q6)



(d) Lectures online reduced assessment marks (Q12)

Figure 2. Summary of quantitative questions in academic staff survey in Table 2.

5. Conclusion

In this paper the perceptions of students and lecturers on Blended learning is discussed. Majority of students accepted Blended learning model adopted at WSU is useful for their learning but they identified face to face teaching is the most useful mode of delivery because they can interact with lecturer and peers in a classroom, they can get answers to their questions during the lectures and the environment is conducive for learning. However, it should be notes here that the survey was carried out for those who were present at the lecture theatre on the say of the survey. Therefore the student perceptions are from a group of students who appreciated face to face teaching and regular attendees for lectures. From the point of view of staff, a significant number of staff stated that the lectures online is not beneficial to students because statistical tracking identified that only a small percentage of students watched lectures online throughout the semester but the numbers increased during the last few weeks of the semester and study break. Also student consultation times increased due to more students requesting to see lecturers to ask the same questions. In some units reduced attendance is reflected in final exam failure rates. When the team design projects are introduced it became very difficult to make groups when students did not know each other. Hence incorporating group assignments in units became difficult, making it difficult to meet some professional competency levels set out by Engineers Australia. As a solution, lecturers suggested introducing more interactive tutorial sessions if a Replacement model is introduced reducing regular class meeting times.

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Credentialing Students in Their First Separations Course-ChE360 Using a Problem Based Approach

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Abstract: Problem-based Learning (PBL) is an approach that challenges students to "learn how to learn," working in groups to seek solutions to real world problems. The process replicates the commonly used systemic approach to resolving problems or meeting challenges that are encountered in practice, and will help prepare students for their careers. In the spring 2016 semester offering of ChE360 at New Jersey Institute of Technology, we added one new feature – simultaneous use of Aspen Plus®. The course is delivered twice per week for 80 minutes per session. In this semester the plan was to deliver new information on the selected separation process in a workshop format in the first part of a week, then use Aspen Plus® simulations in the second part of the week to validate results obtained through graphical construction. Each significant example calculation that accompanied a new topic area such as using the McCabe-Thiele Method to determine the number of theoretical stages along with exit stream flow rates and compositions were subjected to this new course delivery approach. In addition, the students worked in groups on the simulations and were required to document their results in a structured report format and each report was graded as a mini-project. Formative assessment using Students Assessment of their Learning Gains (SALG) resulted in 100% response rates with at least 67% of the class reporting moderate–great gain in understanding content, impact on their attitude, increase in their skills, integration of their learning and helpfulness of their class activities.

Keywords: Engineering education, blended learning, online delivery, students

1. Introduction

The Separation Processes I course is part of the result of a comprehensive curriculum revision that occurred more than ten years ago in order to address ABET concerns regarding the introduction of biotechnology into the existing curricula. The prior offering of the current topics (course outline) was delivered under the topic areas of 1) Diffusion Processes and 2) Equilibrium Stage Operations. Those topic areas were redesigned and renamed Separation Processes I and Separation Processes II, in which Separation Processes I covered traditional separation processes (distillation, absorption and liquid-liquid extraction) while Separation Processes II addressed other selected topics in current practice such as membrane and solids-fluid separations.

It is important to note that with that curriculum change, the notion of mass transfer is now covered simultaneously in a new Heat and Mass Transfer course (Current Approved Curriculum) which is delivered in the semester prior to the Separations Processes I course.

Over the last five years NJIT have been experiencing an uptick in the number of students selecting chemical engineering as their major and this has resulted in larger than normal classes in the junior and senior years over the past two academic years 2014 – 2016. The decision was made to offer two sections of the first separations process course in spring 2016, with the second section assigned to this author. After reviewing the pedagogical approaches that was employed by previous instructors, feedback from the subsequent separations course (Separation Processes II) instructors, along with student feedback from previous course offerings, revealed that expected student learning outcomes were not being achieved. This provided an opportunity to introduce a delivery modification that is expected to increase student engagement in the topic areas to be covered, meet expected student learning outcomes while fostering an active learning environment (Felder et al., 1998). For the spring 2016 section of the Separation Processes course that was delivered by the author, the learning outcomes are:

Students will be able to:

1. Conduct stream balances on separation apparatus
2. Extend single stage separation concept to multistage operations
3. Conduct separation process modeling using both graphical and analytical techniques
4. Apply knowledge gained while obtaining learning outcomes 1 – 3 to multi-component separation processes.

Although these learning outcomes were achieved as demonstrated on various exams during and at the semesters end, this author believes a more significant and lasting measure will be the performance in the subsequent Separation Processes II course which will be offered in the 2016 fall semester.

2. Method of Assessment

Traditionally students' performances are determined through an examination process at the end of various grading cycles during a semester. In this case there were three concept exams and several problems which required both hand calculation based methods and the use of a current process simulation tool. The concept exams reflect individual efforts and constitute 20% of the final grade, and is conducted in closed book mode with one standard (8.5 X 11) hand written sheet of notes.

Each such exam's duration is about 40 min. The problem solving component of the course constitutes 60% of the final grade and involves the submission of a structured report by each Instructor designated group. It is important to note that individual efforts were accounted for in each group (Kaufman et al., 2000). An open book final exam which reflects individual effort and was comprehensive of the semesters work is also given to complete the standard grading component of the course.

In order to assess the level of student engagement, summative assessment using Students Assessment of their Learning Gains (SALG) was conducted early into the spring 2016 semester and a traditional course evaluation conducted by the Institution towards the end of the semester. The SALG website, http://salgsite.org is a free course-evaluation tool that allows college-level instructors to gather learning-focused feedback from students. Anyone may register and use the site. Once registered on the SALG site, one can:

1. Create and use a SALG survey to measure students' learning gains in the course and the

students’ progress toward the course's learning goals.

2. Create and use an optional baseline survey to discover students' starting point relative to course goals.

The students were informed of the upcoming evaluation and the purpose for such an early assessment. The evaluation timeline was selected to include the weekend, which facilitated student’s orientation with their classes and other responsibilities. Below are the questions used in the free course evaluation tool:

Instrument #12290, Separations 1, Spring 2016 Baseline
Administered Fri Feb 05, 2016 - Wed Feb 10, 2016”
Questions
How much did the following aspects of the class HELP YOUR LEARNING:

1. Instructional approach taken in the class?
2. The pace of the class?
3. Participating in discussions during class?
4. Aspen practice in laboratory?
5. Instructor FEEDBACK on your graded work?
6. Explanations given by Instructor?
7. Course Delivery Approach

The course was delivered twice each week on Tuesdays and Fridays. Each Tuesday session begins with a review of the previous Friday’s performance outcomes on a given assignment. This segment of the discourse would transition to the report writing discussion. Depending on the amount of remaining class time, new material would be introduced along with a new example problem to be solved in the computer laboratory.

Each Friday session the class would convene in the computer laboratory where each group would access a set of computers complementing their group (size 2 - 4) which were preselected by the course Instructor during the first week of the semester. A problem to be solved by the class had been given in the previous Tuesday session. At this point, we would proceed to identify and select a thermodynamic package based on knowledge gained from a prerequisite thermodynamics course. The groups would then independently develop their solution strategies and enter the required parameters into the Aspen Plus software with keen attention to the software’s usage and operating guidelines.

The spring 2016 Separations Processes I course is the students’ initial exposure to actually conducting process simulations to obtain results for comparison with those achieved by hand calculation method(s). Therefore it is important that differences in results are explored and explained in the context of a structured report format. This ‘credentialing’ approach is intended to give the students a peek into the professional practitioner’s domain where computational tools are routinely employed to derive results for economic considerations.

It was required that each group developed a project report. The report must contain six sections in the order: 1) Problem Statement, 2) Problem Objective, 3) Method of Solution, 4) Results, 5) Discussion of Results and 6) Conclusion and Recommendation. Some groups were allowed to combine sections four and five if the communication of their findings was improved by using a modified format.

Since a structured report outside of a traditional laboratory environment is new to the class, students needed to be mentored. This includes at least two iterations of each group’s initial submission and at least one face-to-face meeting prior to a final submission. This process is intended to help students clarify and determine what technical information is needed to communicate and support their conclusions and recommendations.

The assigned problems that were used to conduct Aspen plus simulations were a composite of detailed worked out examples appearing in the textbook and selected unsolved problems from the textbook. These were selected because they were anticipated to reflect the students' interest to know how to actually solve such problems when confronted in an industrial setting (Felder et al., 2000).

4. Conclusion

Based on the results from the formative spring 2016 Instrument # 12290 indicated that at least 67% of the class (N = 17) reported highly moderate –great gain in understanding content, impact on their attitude, increase in their skills, integration of their learning and helpfulness of their class activities. The remaining 33% reported little impact – moderate impact.

It is therefore reasonable to conclude that the students valued this course delivery approach as it helped them to learn some of the information processing steps that will be expected in an industrial setting. A summative assessment will be conducted in their subsequent courses to determine how effective this type of problem based approach was.

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Use of the Force Concept Inventory as a Diagnostic Tool for the Teaching of Engineering Students

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Abstract: The Force Concept Inventory (FCI) has been used widely in physics education in both schools and universities in the US and more recently in other countries, such as Australia, Finland and Britain. It provides a reliable method to assess students' Newtonian and non-Newtonian concepts of force and motion. This paper used the FCI to assess the conceptual understanding of newly enrolled Higher School Certificate students in a university engineering program prior to their undertaking the first year engineering physics unit at the university. The analysis of the results of the diagnostic test that was given to the students revealed a marked discrepancy between their Newtonian and non-Newtonian conceptions of force and motion. The analysis of the results provided an insight to the academic staff to find new methods of teaching Newtonian physics which is an essential foundation for engineering studies. Some of these methods included active learning, on-line Socratic teaching methods which emphasised concepts, hands-on and in class demonstrations of the principles and concepts of the topic being taught in the lectures and less talking in lectures but more Questioning and Answering (Q & A).

Keywords: Newtonian thinking, Force Concept Inventory, Newton's laws, On-line tutorials

1. Introduction

The Force Concept Inventory (FCI) introduced by Hestenes, Wells and Swackhamer (1992) and the Force and Motion Conceptual Evaluation (FMCE) devised by Thornton and Sokoloff (1998) have been used extensively over several years both in high schools and universities mainly in the US and more recently in Australia, Britain and Europe. It is a multiple-choice diagnostic assessment tool to test students' conceptual understanding of Newton's Laws of Motion for students undertaking introductory physics courses or units of study. Its strength seems to lie in its ability to be used across national and cultural boundaries in different educational systems with remarkable success. Savinainen and Scott (2002) provide a succinct account of the history of the development of the Force Concept Inventory and its beginnings as the Mechanics Diagnostic Test (MDT). Its ease of use as a multiple choice assessment tool and being "independent of the teacher" as Savinainen and Scott note, "adds to its flexibility and overall strength as an assessment tool". "The questions", according to Hake (1998) are able to "probe for conceptual understanding of basic concepts of Newtonian mechanics in a way that is understandable to the novice who has never taken a physics course, while at the same time rigorous enough for the initiate".

Hestenes, Wells and Swackhamer's (1992) FCI was designed to investigate six conceptual dimensions in the study of forces and kinematics. These are listed below.

(a) Kinematics: Velocity discriminated from position, Acceleration discriminated from velocity, Constant acceleration entails – changing speed, parabolic orbit, vector addition of velocities.
(b) Newton's First Law: With no force, velocity direction constant, speed constant, with cancelling forces.

(c) Newton's Second Law: Impulsive force, Continuous forces,
(d) Superposition principle: Cancelling forces
(e) Kinds of forces: Solid contact - passive, friction opposes motion; Fluid contact – air resistance, buoyant (air pressure)
(f) Gravitation: Acceleration independent of weight, Parabolic trajectory

One of the strengths of the FCI is that it also probes the misconceptions that students bring along as baggage to a first year university engineering class from school and their common sense ideas. These include, for example 'no motion implies no force', 'impetus dissipation', 'greater mass implies greater force when applying Newton's third law', and 'heavier objects fall faster to the ground'. The purpose of the paper is to assess the conceptual understanding of newly enrolled Higher School Certificate students in a university engineering program prior to their undertaking the study of the first year engineering physics unit at the university..

2. The diagnostic test

In order to assess the conceptual understanding of Newton's laws of motion we used the first 21 questions out of the 43 questions in the Force and Motion Conceptual Evaluation (FMCE) devised by Thornton and Skoloff (2002). It is, according to them "a research based assessment instrument designed to probe conceptual understanding of Newtonian mechanics". The reason for using only the first 21 questions was to enable us to get a quick appreciation of the knowledge and understanding of students' views on force and motion (dynamics) concepts. Questions 1 to 7 were on the motion of a sled pushed along on ice with friction ignored. Questions 8 to 10 were on the motion of a cart on a ramp. Questions 11 to 13 were on a coin tossed straight up into the air. Questions 14 to 21 were based on a force-time graph of a car (the friction was assumed to be so small that it could be ignored).

The diagnostic test was administered to 125 first year engineering students on the first day of term. They were randomly selected from a cohort of 550 students who had enrolled to study engineering at the university.

3. Results of the diagnostic test

The percentage of students who got Questions 1 to 21 correct is shown in Table 1.

Table 1 Results of diagnostic test

Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Q12	Q13	Q14	Q15	Q16	Q17	Q18	Q19	Q20	Q21
11	6	19	19	27	8	19	4	6	15	9	9	23	4	90	12	3	8	7	15	10

Over 90% of the students got Question 15 correct. This question which relates to a graph of force against time asks for the force acting on an object (car) at rest. This is the only question where the students' common sense view and the Newtonian view is the same. The fact that less than 15% of the students were able to read each of the graphical questions (Q 14, 16, 17, 18, 19, 20 & 21) correctly showed that their knowledge of reading graphs was weak. It was envisaged that students would have done better in answering the graphical questions as a number of them came from non-English speaking backgrounds. But this was not the case.

Question 5 (The sled was started from rest and pushed until it reached a steady [constant] velocity to the right. Which force would keep the sled moving at this velocity?) was intended to identify students who understood Newton's First Law of Motion. Only 27% of the students got this question correct while for Question 2 (Which force would keep the sled moving toward the right at a steady [constant] velocity?) which was supposed to have elicited the Newtonian answer of zero net force for motion at constant velocity revealed that only 6% of the students got it correct.

23% of the students got Question 13 correct but only 9% got Question 11 correct and only 8% got Question 12 correct. They were asked what is the force acting on the coin when it is moving upward after it is released (Q11), the coin is at its highest point (Q12) and the coin is moving downward (Q13). They were not able to appreciate that the force of gravity was downwards. 19% of the students got Questions 3,4, and 7 correct. These questions were about a force applied to a sled and its motion either slowing down at a steady rate (constant acceleration) when moving toward the right [Q3], or its motion speeding up at a steady rate (constant acceleration) when moving toward the left [Q4], or its motion slowing down at a steady rate (constant acceleration) when moving toward the left [Q7].

4. Discussion

A number of reasons were identified as to why students had a poor appreciation of Newton's laws of motion and a non-Newtonian way of thinking. In interviews with the students it was very common for students to note that the methods used in the teaching of physics in schools were more often than not based on passive-student teaching, laboratory sessions were usually recipe orientated rather than inquiry based and they had quantitative problems to solve. In solving the quantitative problems students were given formulae to plug in numbers to get the answers without discussing the concepts that were being studied to solve the problems. The teaching method was traditional without being conceptually based and hence they found it difficult to answer the questions in the diagnostic test correctly even though there was no mathematics involved. Students also noted that in some schools there were not much hands-on physics experiments for them to do. That meant that they could not experience the physical manifestation of the concept in the laboratory.

As we carried out the interviews it was becoming quite clear that the teaching of Higher School Certificate physics in schools was not effective in teaching conceptual physics. 70% of the students noted that they used their common sense everyday ideas to answer the questions. A similar situation was found by Thornton and Sokoloff (1998) and Hestenes, Wells and Swackhamer (1992) in their studies of American students. This in a way explains the low percentage of students who gave the correct Newtonian answers.

Another issue was the demographics of the students. The university is located in an area with a very high population of recent migrants including refugees to Australia. This is also compounded by the Australian Government's policy of increasing the number of students from low social economic status backgrounds for equity reasons. Statistics from the University's Administration Department showed that only 55% of the students speak English at home while over 45% of the students speak languages other than English in their everyday conversations. This is probably one of the additional reasons that students have difficulty in understanding the complex conceptual language of physics which is written in the English language.

There was also the issue of the language used in the diagnostic test and that used in secondary and tertiary physics textbooks. This refers to the definition of acceleration in the diagnostic test. An attempt was made to identify any inconsistencies in the definitions and language used in the textbooks. Two university physics textbooks, viz: University Physics by Young, Freedman and Bhathal (2011) which is the textbook the students use and Modern Physics by Serway (2014) were compared with an HSC textbook written by Warren (2008), viz: Excel which is a popular physics textbook used in schools in Sydney and New South Wales. University Physics describes constant acceleration as follows: "The simplest kind of accelerated motion is straight-line motion with constant acceleration. In this case the velocity changes at the same rate throughout the motion". Serway describes constant acceleration as follows: "the velocity of the object changes at the same rate throughout the motion". The HSC textbook Excel describes constant acceleration as follows: "the time rate of change of velocity". This refers to the sled Questions 1 to 7. In the diagnostic test the following words were used in the question: "The car moves toward the left and is speeding up at a steady rate (constant acceleration)" and in another question: "The car moves toward the right and is slowing down at a steady rate (constant acceleration)". The definitions of acceleration used in the University and HSC textbooks led to some confusion amongst the students. The students also confused the concepts of velocity and acceleration.

5. Conclusion

The Force Concept Inventory (FCI) and the Force and Motion Conceptual Evaluation (FMCE) have been found to be excellent tools to investigate the Newtonian and non-Newtonian thinking amongst students who have just enrolled in university engineering studies and in particular engineering physics, which is a compulsory unit of study for the engineering degree in all the universities. The diagnostic test has led to the introduction of a more active learning regime in the teaching and learning of engineering physics.

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Effective Teaching Method for Engineering Education from Student's Perspective

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Abstract: Education system involves two primary complementary processes: learning and teaching. A successful implementation of this system depends on synchronisation of these two processes. One the receiving end, students learns by utilizing different mediums such as hearing and seeing and by applying different methods such as memorizing, visualizing or logically understanding. One the delivering ends, teachers instruct by utilizing different approaches: visual or auditory, face-to-face or online, theoretical delivery or practical demonstration and so on. In complex subjects such as of engineering education, mismatch often exists in the system between the receiving and delivering point of instruction. As a result, majority of students have performed poorly in examination, students get discouraged about the course, and themselves, and in some case change to other curricula or drop out of school. Academics know something is not working or begin to wonder if they are in the right profession. Most seriously, society loses potentially excellent engineers. However, promising future can be speculated on the minimisation of this gap as extensive research, workshop and conferences are in place to improve the education system. Still, only few can be found that specifically focuses on improving technical education system such as engineering which is very important as graduates from this school are expected to make significantly sensitive decisions to the community such as designing of bridges, maintaining electricity production or ensuring reliable water supply. In this paper, some effective alternatives teaching methods particularly significant in engineering education and which teaching methods are preferred by most engineering students are discussed from student's perspective. The suggested teaching style will improve the quality of teaching and that will be effective for students and comfortable for the professor will evolve naturally and relatively painlessly, with a potentially dramatic effect on the quality of learning that subsequently occurs.

Keywords: Effective teaching method, engineering education, student's perspective

1. Introduction

Engineering is an essential and sensitive part of education as it shapes skilled individuals in whose decisions depend safety of mass population in all aspects of a society: whether it is infrastructure such as roads and bridges, or industrial environment such as mining or power generation or even natural calamity assessments like tornado and landslides (Glaser, 1984a, 1984b; Mager, 1962; Ramsden, 1979). But it is very unfortunate that the methodology of delivery of such a crucial subject is generally very uncreative, theoretical and unappealing (Felder & Silverman, 1988; Stice, 1976; Waldheim, 1987). Often it is just about getting required scores to get a degree or, on the upper level, getting record grades. But, in all circumstances, the 'book'-ish methodology of instruction severely lacks in development of engineering intuition and innovative thinking skills or acquaintance to engineering practice and work-relevant culture (Cross, 1993; McCaulley, 1976). As a result, graduates may often find themselves at a puzzling situation after getting a job even though they are so well proficient in theoretical knowledge (Felder, 1987). Hence, comes the so-called (often unpopular among fresh graduates) term of 'local experience' which ensures that the potential incumbent is evidently suited at a practical scenario. This in fact is a strong indication that there is serious lacking in the way engineers are prepared in the engineering institutions (Bloom & Krathwohl, 1984).

There are other disciplines such as 'general education', 'educational psychology' where extensive work has been done to renovate the methodology of education to inhibit, if not eliminate, such issues (Entwistle & Ramsden, 1983; Stice, 1987; Swartz & Perkins, 1989). But they have not been tried on engineering education. And when delved into the style by which the throbbing young and fresh minds are instructed, it is found that, other than some evolution in tools of instruction being introduced like computers, calculators and internet, basic contemporary mode of teaching can be comparable to 'old school' methods as far as the '50s or even further back where the students are bogged down by loads of information being stuffed in a limited time of 4 years.

This paper suggests that there needs to be radical change in method of instruction in engineering where out-of-the-box ideas are introduced. The ideas include introduction to real-world scenario when instructing, distancing from one-subject-at-a-time mode of delivery, team-work based practical interactive education, inclusion to scope of demonstrating innovative skills and critical judgement and many more. The observation is presented in 3 parts: a) preparation of course content b) instruction method of course and c) evaluation process. Authors expect this study will give valuable insight to the possibilities of upgradation of engineering education from a student's perspective.

2. Preparation of Course Content

The traditional way how course content is prepared emphasizes on the point that all course outlines have been covered as such that at the end of the course a student will have theoretical background on the subject in concern. The idea that works beneath is that once a student is introduced to a technical knowledge to a reasonable depth, through successful outcome from exams and tests the attainment of the student is certified to have mastery in skills. However, instructional objectives are not often clear on specific goals on how the skill is relevant to the receiver except by a brief idea with some superficial examples at the beginning of a course. And it is neither explained to the student what is expected from them at a practical level at the end of successful completion of the course nor is it informed what the student has achieved at the end of the course to what level of mastery in the subject he has gained at an applicable role. This paper recommends that such important points need to be clearly identified at the time of curriculum preparation based on skills such as: knowledge, application, analysis, synthesis and evaluation correlating to realistic scenario. A detailed description of these points can be found in (Bloom & Krathwohl, 1984).

2.1 Relevance of course material

Once the objective is clearly identified, the course material should be prepared in light of the objective. The most common issue with this part of preparation is that the material is generally made in such a way that students cannot relate to from their existing background. They find themselves apparently learning new stuffs and are expected to digest with an attitude of trusting the instructor that he/she knows what is being taught is useful. This approach results in lack of interest on the subject and average students just want to get over with it with focus on what they are really interested in: a degree and a job. So, it should not come as a surprise that often students perform poorly in evaluation process even though they have regularly attended the course program. This paper suggests that careful consideration be given to link the new subject to the existing knowledge of students from their current qualification which will bring interest to the subject and students will be inspired to get involved for more than mere attainment of scores in the finals.

2.2 Physical and Analytical Information

Engineering education often involves abstract information accompanied with practically observable knowledge. Abstract information includes concepts, numerical formulae, concepts and theories such as newton's laws of motion while practical knowledge means experiments and applications such as motor vehicles and production industries. Generic course content preparation often separates the two scope of engineering knowledge or even if considered in the same course the importance of balancing them is overlooked. It is expected that students are to find the connection later on their own based on their own necessity on job or elsewhere. This paper suggests that abstract information should be closely tied to practical application throughout the course content rather than separating them and it should be ensured that students are made aware of these ties. It is much easier to do so nowadays with the aid of visual illustrations and virtual demonstrations. This approach ensures that students rely less on the memories to hold on to empirical knowledge but rather these information are linked to visual observations in their mind making it easier for them to capture it for longer period.

3. Instruction Method

Once the course content is prepared, the next most important thing to consider is how the content is to be delivered to the students. The common method of instruction for a course is that instructor introduces students to the course; then goes into the subject through several chapters one by one. Students are expected to receive them quietly, take notes wherever they can. Their whole focus understandably remains on which part is important to the exam. This attitude destroys the whole objective of developing mastery and skill that is crucial in later life for student's career as well as the employer (Felder & Brent, 1999). This paper proposes two following approaches in the instruction method.

3.1 Interactive learning in class

Each topic will be delivered in a manner that students can relate to with their existing knowledge as suggested in preparation of course material. The topic should be exemplified with as many practical scenarios as reasonably practicable. The problems related to the topic will be discussed where students will be asked to identify the issues from the case (Wood, 1999). Of course, students will not be able to fully grasp the problem but the effort to try to grasp the matter from existing knowledge is of immense importance. So, the instructor will complete the issues in the case study for the next step, which is the solution. Traditional method is that students are given the method of how the problem is solved which then students try to memorize (Johnson, Johnson, & Smith, 1999; Ramsden, 1992). But this paper suggests that a strategy is first laid out on how the problem can be solved. Schematic diagram can be very useful in this approach. Then the solution is presented step by step according to the strategy where students participate at each step. Finally calculation is completed and results are verified wherever possible. Throughout the process, students are supposed to participate actively.

3.2 Cooperative environment

Traditional way of classroom environment is that students sit individually in seats staring at the black/white board or large screen waiting for the course to be delivered (Woods, 1998). This paper suggests that small groups should be formed in classes where students sit together. The interactive learning suggested earlier should not be just instructor-student but also student-student (Mancillas & Sisson, 1989). Of course, instructor will have the authority to moderate such interactions to maintain discipline in the classroom so that the environment does not get chaotic. There should be two types of assessment introduced to this sort of method: a) individual: where individual student participation is acknowledged b) teamwork: how to the team is working with respect to others. However, emphasis should be on teamwork as this is not to be viewed as an exam-type situation. Careful considerations should be given in forming the groups. A group should have students of mixed abilities which can be easily found from quizzes. Assignments should be given to teams where students are to be scored on their performance together. The teams should be maintained because bonding and syncing is an important part of team work which is an essential qualification in real work environment.

4. Evaluation Process

After the course has been delivered to the students, finally comes the evaluation process. This is a very important part of education because of two reasons: a) this works as an indicator of the level of acquiring of skill by the student b) student focuses on it regardless of whatever teaching method is used from natural inclination to pass the course. Traditional method includes in-term quizzes and final exams where students are expected to obtain a score higher than a level which is called pass mark which ensures that they are not to redo the course. The pass mark should indicate that a student has achieved reasonable mastery over the course. The flaw in this method is that students are too focused on what is to appear in the exam paper and whether they have enough stored in their memory to write the right things on the paper. Understanding of the course becomes irrelevant to the student. This may result in some students having high scores while little of that knowledge can he use in practical application. This paper suggests that evaluation process is to be designed in light of course content preparation where objective clearly defines what achievement should indicated what kind of skill level. The contents of evaluation should include several levels: basic understanding, creativity, innovation, problem solving and excellence. While the mid-term quizzes and final exams can still be used as a tool of evaluation, the marking and segmentation should clearly show what a student has achieved through that evaluation. This will give an understanding of the student, the instructor as well as future employers to what is expected from the student. Timing of the exam should be considered at such that students are not pressed too much in time limit. They should have some sort of time to reflect upon what they are doing rather than just pouring out from practices and memories. Finally scoring should be done on an averaging method along with the traditional way of marking. This will give students idea of their relative performance from the class as well as what level of mastery they gained. This is also an evaluation process for the instructor on how well the course content has been delivered.

5. Overall Considerations on the Environment

In all times, the instructors are to make efforts to make the classroom a positive and lively environment to maximize the receptivity of the students. Students should develop a sense of importance of what they are learning. There should be a respectful yet friendly relationship between instructor and students. Randomly achieving students are to be recognized on their class room performance which will encourage them and the others on enhancing their performance level. This paper suggests there be extensive training program for instructors specifically for engineering faculty where such points are emphasized.

6. Conclusion

As civilization races towards technological environment at a high speed of advancement, it is essential to revolutionize the engineering education as its products are the future backbone of the society. Although engineering students generally come from a somewhat strong analytical background through admission process, these innate qualities should be nurtured and flourished based on strong engineering intuitive foundation that once they pass, they are reasonably ready to dive into the uncompromising realm of technical complexity. While this paper acknowledges that fact that there is an ocean of possibilities by which learning styles for engineering education can be designed, it suggests some key points that can be kept in consideration to ensure the effectiveness of the design that, from a student's point view, is deemed beneficial. It may seem that the reformation expected in this paper is unrealistic from an instructor's point of view, but a systematic effort to development while keeping in mind that instructor is not under unreasonable pressure may produce a balance in method where the engineering education becomes more fruitful.

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Improving student performance through engagement

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Abstract: It is generally accepted that student learning is closely correlated with their level of engagement. Despite the variety of interpretations among academics from different disciplines and from within disciplines about what constitutes 'engagement', most agree that active participation by students improves their learning. Engineering programmes, by virtue of the practical and applied nature of the academic area, provide many opportunities for positive interaction between academics and students. Typical opportunities include laboratory exercises, group-based project work, guest lectures by industrialists, design projects and so on. It would therefore be expected that engineering students would be very 'engaged'. However, we know from experience that this is not always the case.

This paper presents an approach taken by course teams in the School of Engineering at Ulster University in the development and re-organisation of the year one curriculum in its engineering and technology programmes. Against a background of competing constraints familiar to many higher education institutions such as, student progression statistics, teaching sustainability, professional body requirements, employer expectations, economic pressures, etc., the year one curricula were rationalised and streamlined. One facet of the re-organisation was an increased emphasis on the development of those 'enabler' skills such as time management, study skills, self-discipline and self-esteem which empower students to actively participate, take responsibility, and become more engaged with their studies at university. Preliminary results show a reduction in non-completion rates and a corresponding improvement in student performance.

Keywords: Engineering education, Enabler skills, Curriculum redesign, Student transition

1. Introduction

The global economic downturn of the late 2000s, prompted the UK government to set about rebalancing its economy. A strategically important aspect of this was the renewed focus on Science, Technology, Engineering and Maths (STEM) careers as being essential for the long-term economic prosperity of the nation. There have been a number of national initiatives, for example, The IET Faraday Challenge [1] and The Big Bang [2], supplemented at local level by regional initiatives such as the regional Science Festivals [3] and the BBC micro:bit [4]. Ulster University, as a regional university in Northern Ireland is also active in this area, participating in and pioneering a range of activities aimed at inspiring school children to consider engineering as an exciting and worthwhile career.

One of the major issues that restricts an already small supply of engineering graduates is the relatively high non-continuation rates for engineering and technology subjects in higher education, particularly among those students who have not studied Maths and Physics to 'A' level or equivalent pre-university entry level [5]. At Ulster University, although previous study in these subjects to 'A' level is preferred, to-date it has not been a pre-requisite to admittance to the majority of our BEng Hons courses. All the BEng Hons courses in the School of Engineering are accredited by both the Institution of Engineering and Technology (IET) [6] and the Institution of Mechanical Engineers (IMechE) [7] for partial CEng status so that graduates from the programmes can, in due course and subject to the appropriate 'Further Learning', become CEng registered and become Members of the engineering professional body of their choice. In higher education, the challenge exists to develop a curriculum that satisfies the requirements of stakeholders, such as, the University, the professional engineering bodies, students and employers. In addition, the transition from school to university needs to be managed so that any gap that exists for students between secondary and tertiary level study is appropriately bridged.

The revised Accreditation of Higher Education Programmes guidelines (AHEP3) [8] developed by the UK Engineering Council outlines the UK standard for professional engineering competence and describes for each level of accreditation the expected competence level with respect to: Science and mathematics; Engineering analysis; Design; Economic, legal, social, ethical and environmental context; Engineering practice; and Additional general skills.

The framework for curriculum developers at Ulster is provided by the Quality Assurance Agency's (QAA) subject benchmark statements for the engineering discipline [9] and Ulster University's own expectations of its graduates [10]. Successful programmes are required to provide students with sufficient opportunities and the necessary support to develop their benchmark skills and key competences to the appropriate level.

A study of graduate recruiters in 2008 ranked the five most important generic skills and capabilities in new graduates as: communication skills, team working skills, integrity, intellectual ability and self-confidence [11]. In addition, engineering employers identified the six main areas of importance for them in recruitment as: practical application, theoretical understanding, creativity and innovation, team-working' technical breadth and business skills [12].

Despite the high tuition cost of a university education in the UK it is a disappointing phenomenon that many students fail to capitalise on opportunities at university to develop and hone the 'softer' professional skills that they will need to be successful in the fast-paced, evolving, and often uncertain work environment of the future.

At tertiary level, engineering programmes tend to have higher attrition rates than programmes in other subject areas. In the UK, the overall non-continuation rate for engineering and technology subject disciplines is 15.6%, almost 1.5% higher than the average for all subjects [13].

With the introduction of the National Student Survey (NSS) [14] in 2005 for all students in the final year of their studies in Higher Education Institutions (HEI's) in the UK and the advent of the Key Information Sets (KIS) [15] in 2012, UK universities are faced with a scenario where data relating to how students actually feel about their courses is in the public domain and is influencing university league table positions and programme choices of prospective students. Fielding et al describe the NSS survey as measuring 'satisfaction in a particular context, aligned to educational experiences of how students perceive the quality of their learning experiences' [16]. Ramsden interprets the survey information as 'a window into how our designs for learning are experienced by students', and goes on to indicate that the survey should lead to practical changes to enhance the quality of the student learning experience [17].

Faced with challenges around drop-out rates and the desire to enhance student satisfaction with their studies, curriculum developers in the School of Engineering at Ulster University designed a study to elicit students' views on their participation levels and to find out what measures the School could take to improve their engagement.

2. Perceptions of student engagement

There appears to be no universally accepted definition of 'student engagement'. Swaner [18] argues that student engagement is associated with both the student's learning perspective and with the student's 'involvement with society beyond the classroom'. Others, such as Carini et al [19] and Astin [20] suggests that 'time and energy spent on fruitful activities' is what best describes the engaged student, and that the more time and energy gainfully spent by the student the greater the likelihood of the student experiencing enhanced learning. There is a broad general consensus that engagement relates to effort and the concept of 'more' [21] and that this in fact is the key predictor of success [22].

2.1 Re-design of the Year 1 curriculum

The School of Engineering at Ulster University is comprised of around 900 undergraduate students, with approximately 260 students per annum entering at the year 1 stage. A total of 120 credits are taken on each year of study and a range of honours and master's programmes are offered in the broad areas of electrical, mechanical and biomedical engineering. In the 2010-11 academic year, the School reorganised its year 1 provision underpinned by two broad cross-cutting aims: firstly, to reduce the student drop-out or non-continuation rate and secondly to improve the student experience.

Prior to 2010, first year drop-out rates approached 33% averaged over all the School's programmes: student attendance was not closely monitored and staff resource was thinly spread across a large number of modules. In the year 1 re-organisation, a number of 'enabler' modules were specifically designed so that they could be taken by all students in the School; the increased lecture size was offset by the introduction of an associated small tutorial group size. A year 1 co-ordinator was appointed from academic staff as the 'go-to' person for student concerns and to monitor student attendance, and small tutorial groups were formed that carried through from the start to end of the academic year. In line with many other HEIs offering engineering programmes, the number of female students on our programmes is relatively small and care was taken when students were assigned to a particular tutorial group such that no group comprised of only one female student. One of the modules introduced was a 20 credit module, Professional Studies, which provided students with developmental opportunities in real-life projects directly related to their particular engineering programme. It focused on building the students' self-esteem and motivation and sought to stimulate them to 'want' to learn thereby providing them with the study skills or 'enabler' skills that will allow them to be successful, fully engage with their studies, enjoy their university experience and develop into active professional engineers in society. A team based project, based on the Formula Student concept, was utilised to allow students to develop their employability skills in a competitive fun environment. Limited streaming was used for those numerically demanding modules so that the analytically competent students could be stretched whilst the students with lower entry grades were supported through additional voluntary face-to-face and online tutorial support.

3. Design of study

A study was carried out on all years of students on the Mechanical Engineering and Engineering Management programmes at Ulster. These programmes were selected as they comprise the JACS (Joint Academic Coding of Subjects) Mechanical, Production and Manufacturing Engineering grouping at Ulster. They represent approximately one third of the student numbers in the School of Engineering at Ulster. A questionnaire, broadly based on the approach used Heller [23] and that used by Bjorland and Fortenberry [24], comprising a mix of open and closed questions was administered to students. The aim of the study was twofold: firstly, to determine students' perceptions of their participation levels and secondly, to elicit students' views on what the School could do to improve their engagement. The overall response rate was 45% with approximately equal numbers of questionnaires returned by each year's students: the data was analysed using SPSS [25].

An analysis of the student responses to the open questions was carried out and suggestions were grouped into broad category headings which were then used as discussion topics in subsequent student-staff focus groups. The student-staff focus groups were structured so that each group was comprised of students (eight students in each group) across all years of the programmes and staff essentially performed a facilitation role and used the focus groups to validate the free responses.

4. Perspectives on student engagement

4.1 Staff perceptions of engaged students

Staff teams discussed informally their perceptions of full engagement from students. In essence, staff felt that the fully engaged student should:

- attend all timetabled classes, be prepared, be on time, and contribute enthusiastically in class discussion as the opportunity arises
- occupy themselves with purposeful activities when they are not in class
- devote at least 35 hours per week to their studies inclusive of class contact time

4.2 Student perceptions of engaged students

4.2.1 Questionnaire analysis – closed questions

Analysis of the questionnaires, showed that the majority of students in each year were familiar with the term 'engagement'. Averaged over all years, 55% of students were familiar with the term with 70% of students in the final year of their studies reporting familiarity with the term.
Figure 1 shows the students' responses when they were asked if they participated fully in their studies: responses show that 85% of studies feel that they did indeed participate fully in their studies. When students were asked if they considered it important to attend all of their timetabled sessions, only 65% of respondents agreed as shown in Figure 2. These results show that students do not necessarily associate full participation in their studies with full attendance at timetabled sessions.

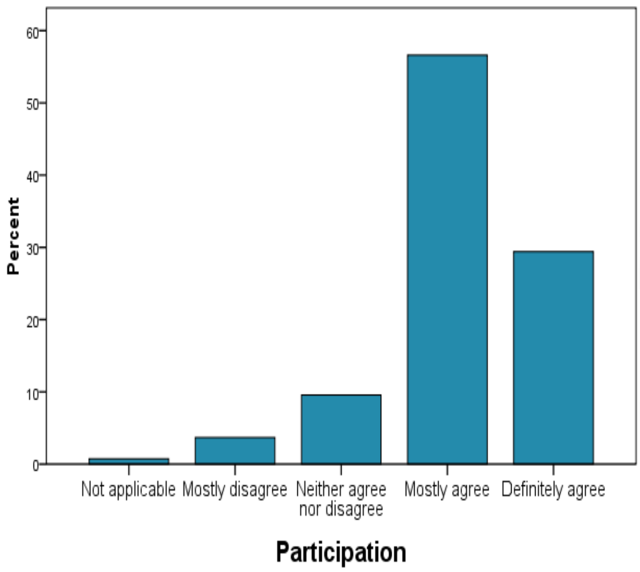


Figure 1 Students' perception of their participation levels

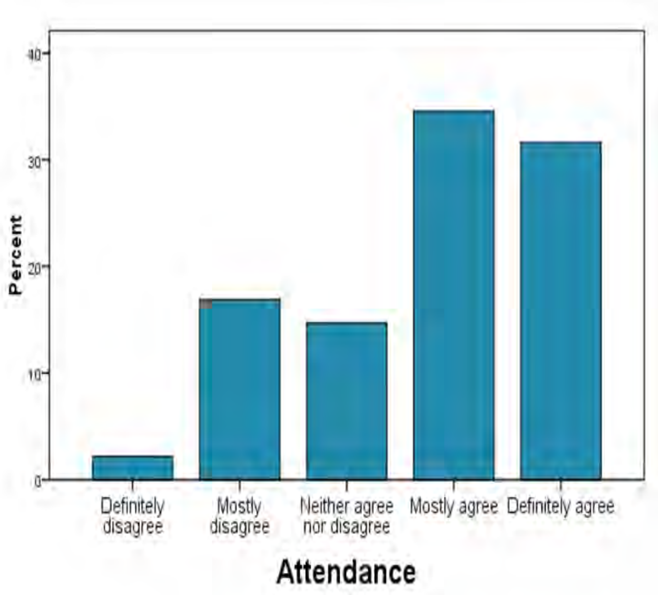
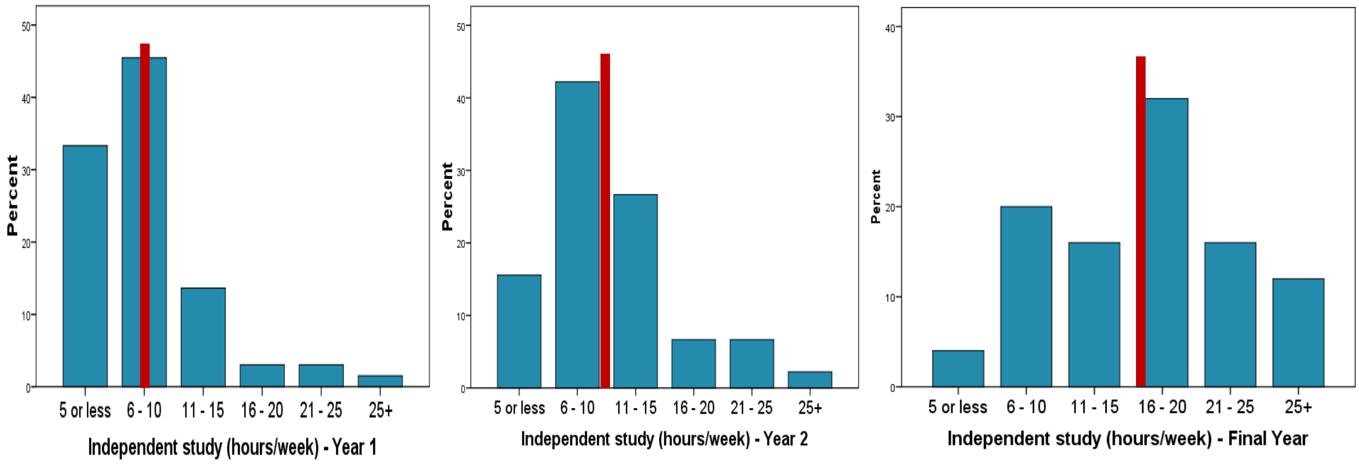


Figure 2 Students' perception of the importance of attendance at all timetabled sessions

Figures 3a-c shows the average number of hours that students reported spending on their studies per week outside of timetabled hours. In Ulster, first and second year students are timetabled for class contact time for 18-20 hours per week and in final year, they are timetabled for 15 hours per week. The mean value is indicated by the red line on the graphs and it is evident that the number of hours of independent study undertaken by students increase, as students mature and assume more responsibility for their own learning.



Figures 3a-c Number of hours of independent study undertaken by students on each year of study

4.2.2 Questionnaire analysis – free response questions

Students were invited to provide up to three suggestions that the School should implement that they believed would enhance their engagement. As expected, there was a higher response rate to the closed questions than to this free response question but overall the survey resulted in eliciting many students' suggestions. The responses were grouped into broad headings as shown in Table 1. For example, 56% of all survey suggestions were categorised as 'Relating theory to professional practice' and so on. Student focus groups were then used to explore the students' responses. The students' suggestions, ranked in order of 'most-to- least' helpful were grouped into five broad categories:

- Relating theory to practice
- Lecturer attributes
- Programme organisation
- Team-working
- e-Learning opportunities

Table 1 Student suggestions for practical measures to improve their engagement with their studies

Student-staff focus group category	Student suggestions to improve engagement	Free response frequency %
Relating theory to professional practice	Real–life assignments Practical laboratory work Industrial visits	56
Lecturer attributes	Interested in students Enthusiasm for subject Clear communicator Approachable	44
Programme organization	Timetabling Balanced assignment workload Fewer large lectures	38
Team-working	Design-based assignments Small group tutorials	29
e-Learning opportunities	Podcasts, BBL, CAE software, Lectures and assignments online	17

The course teams have sought wherever possible in their individual modules, to make incremental changes that incorporate the suggestions illustrated in Table 1 to help improve student engagement. The overall attrition rate in the School of Engineering has improved significantly since 2010 and attrition rates from the Mechanical Engineering and Engineering Management programmes are now broadly in line with School expectations and only slightly higher than the national average value. The trends over the study period are shown in Figure 5.

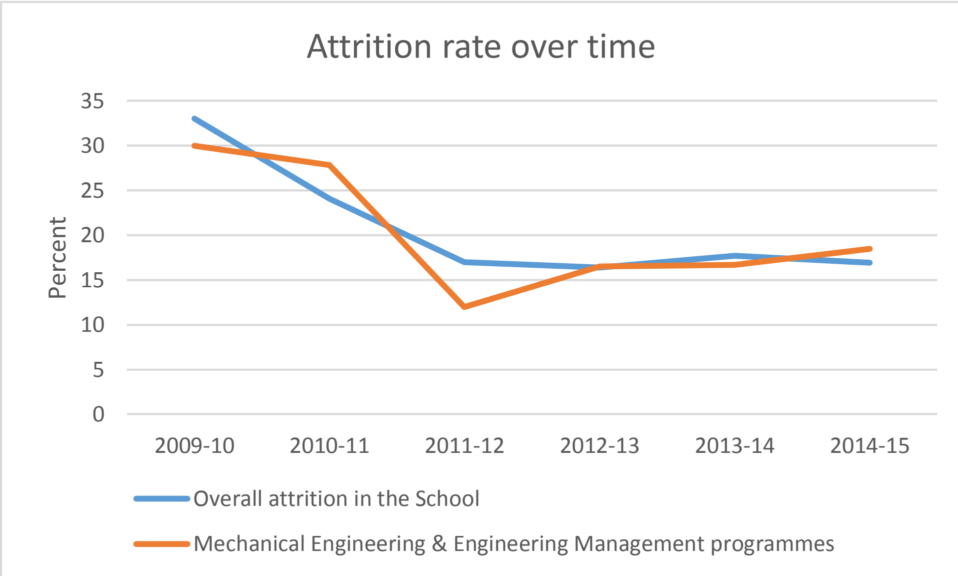


Figure 5 Trend in attrition rates over time

The decrease in attrition rates over time, indicates that students are now more likely to continue with their courses and so it is pleasing to note the improvement in student performance that has also taken place. Exit awards are available for those students who fail at a particular stage from year 2 onwards on the programmes and are awarded in recognition of having successfully completed an earlier, lower level stage of studies. The first graduating cohort following the year 1 re-design in 2010-11 was in 2013-14. It can be seen in Figure 6, that around two thirds of the graduating cohort obtained at least a second class honours, upper division, although the 2014-15 cohort shows this percentage has fallen back to be more in line with Ulster's norm of around 60%. The figure also shows that the percentage of students completing their degrees with a lower second or third class honours has increased with fewer numbers of students leaving with an exit award. It is believed that the good study practice and enabler skills developed in students in year 1 of the programme has led to students becoming more engaged with their studies and as a result, increased numbers of students are now able to successfully complete their degrees and realise their potential.

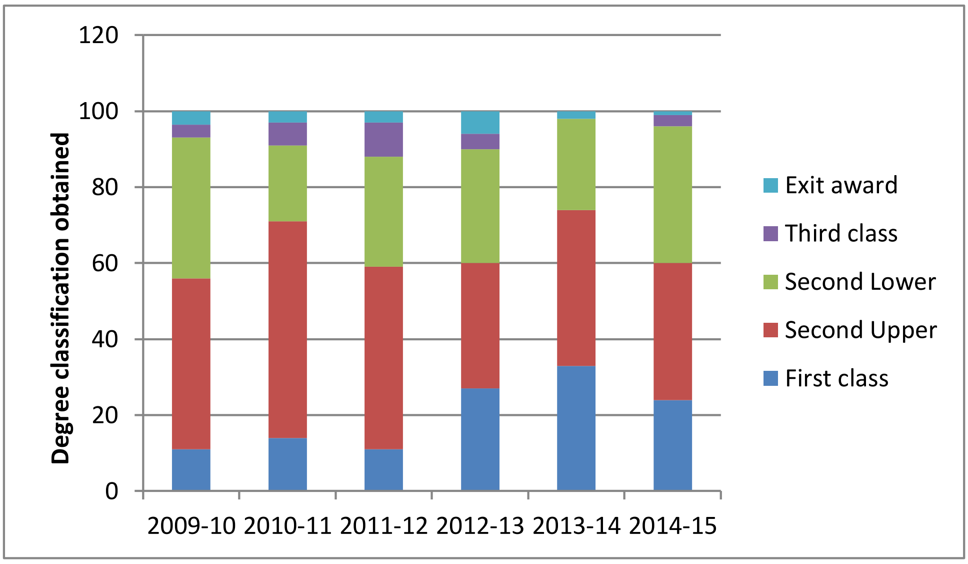


Figure 6 Graduating performance of students 2009-10 to 2014-15

5. Conclusion

This paper describes a study that was conducted on students on the Mechanical Engineering and Engineering Management programmes at Ulster University following a re-design of the year 1 curriculum. Specific modules were introduced that sought to develop good study skills in students at an early stage of their programme so that they would engage more fully with their studies. A significant reduction in attrition levels has been achieved and the overall performance of students at the completion of their studies has improved, as measured by increased numbers of students obtaining lower second or third class degrees.

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Past, Present and Future Trends in Electrical Power Engineering Education

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Abstract: The paper deals with the field of electrical power engineering and its relevance and sustainability in the future. With increasing concerns about global warming and green house gases, the electricity energy generation, conversion and utilisation will play an important part in future growth and development. Electrical Engineering is a well established field of study and power engineering is the oldest sub-discipline of it. Electrical Engineering field has expanded much rapidly over the last few decades with rapid advances in solid state electronics, communication, computer systems and microprocessors, computer control, artificial intelligence etc. It was rather natural to accommodate new developments by removing or rationalizing existing course structures. Due to huge new developments, new degree programs have emerged as specialist disciplines e.g. electronic engineering, computer engineering, communication engineering, control engineering and of course electrical power engineering and even highly specialised sub-discipline of photovoltaic and solar energy. Power engineering education has gone through various stages including earlier golden era of large scale electrification, later an era of automation and computer control and more recently an era of restructuring / deregulation and privatisation and energy conservation. It is expected that the future of power engineering will concentrate on alternative electrical energy sources, power quality issues, smart drive systems, distributed generation and electric vehicles and better forms of storage, use of superconductors and other highly efficient and smart materials.

Keywords: Power Engineering Education, Engineering Education, Electrical Engineering Education

1. Introduction

Electrical Engineering is a well-established field of study and power engineering is the oldest sub-discipline of it. Electrical Engineering field has expanded much rapidly over the last few decades with rapid advances in solid-state electronics, communication, computer systems and microprocessors, computer control, artificial intelligence etc. [1-4]. It was rather natural to accommodate new developments in already crowded curricula by removing or rationalising existing course structures. Due to new developments, new degree programs have emerged as specialist disciplines e.g. electronic engineering, computer engineering, communication engineering, control engineering and of course electrical power engineering and even highly specialised sub-discipline of photovoltaic and solar energy[5]. Power engineering education has gone through various stages including earlier golden era of large-scale electrification, later an era of automation and computer control and more recently an era of restructuring/ deregulation, privatization, energy conservation and distributed generation and smart grids [6-16]. It is expected that the future of power engineering will concentrate on alternative electrical energy sources, power quality issues, smart drive systems, distributed generation and electric vehicles and better forms of storage, use of superconductivity and other highly efficient and smart materials [17-23].

Large numbers of Australian and overseas universities eliminated power engineering teaching and research from their curriculum due to lack of student interest. It has produced a crisis in power and energy engineering education. With restructuring and rationalisation in electric utilities, many qualified power engineers have left the industry and very few have taken their positions. There is ensuing crisis in industry and academia in the next few years when such an important area of economic activity will not be well maintained, though some universities have revitalised their power engineering programs. It is essential that power engineering should be taught as an essential component of any electrical engineering program with more emphasis on power conservation, new forms of electricity generation including renewable sources, embedded/distributed generation, power quality and EMC issues [19-23].

2. Present state and future challenges in teaching

The traditional components of electrical power engineering are as follows:

- Electrical machines
- Electrical drive system
- Power electronics
- Power system analysis
- Power generation, transmission and distribution
- High voltage engineering
- Power system protection and control

Some newly emerging areas of technologies also require the essential elements of electrical power engineering e.g. Mechatronics and robotics require essential of power electronic and control, electrical machines and drives.

Electrical Machines

There is very little teaching done at undergraduate (UG) level in the designs of electrical machines. It is more devoted from a user point of view. There is need to include some modern developments in such areas, such as

- Permanent magnet machines
- Brushless motors
- Stepper motors
- Variable reluctance drives and control

Power Electronics

This subject needs to be taught more from a practical application point of view. There needs to be more of an emphasis on new developments.

- Power supply design
- Applications in power systems
- Application in traction and electric and hybrid vehicles
- Soft switching techniques
- Issues resulting from power electronics e.g. power quality and EMC
- Power Electronics applications in renewable energy conversion and energy storage

Electrical Drive Systems

It covers electric motors, power converters and associated control as an integrated system. This area needs to be taught as an integrated area with possible use of multimedia and computer simulations. New developments in microprocessors, control techniques and DSP applications and dynamics can be easily incorporated.

Power Systems Engineering

In addition to traditional area, some new additions need to be included by moving some of traditional topics such as load flow, planning etc. to postgraduate (PG) level.

- Distributed/ embedded generation
- Effects of penetration of new and renewable energy sources
- Power quality issues
- Developmental electricity markets, short term load forecasting
- Business aspects of electricity markets
- Smart and micro-grids and smart metering
- Smart load management

Electromagnetic Compatibility (EMC)

It is an old area of traditionally of interest to communication engineering. It has taken on significance due to application of power electronics in industry, computer application and transportation. There are stringent standards/requirements covering such issues as EMC certifications. The author believes that it is to be introduced at UG level, which can be of interest to all electrical/ electronic/ computer/ telecommunication engineers or even mechatronic engineers. It can easily cover important areas of EMI/ EMC, testing, ramifications and mitigation techniques.

Renewable Energy Systems

This subject can cover fundamentals of generation and distribution systems, power electronics. In addition to this new areas are to be included.

- Wind and solar energy and conversion to electricity.
- Fuel cell and other alternative sources of electricity generation, OTE, wave energy.
- Economics of green power.
- Operational aspects of large penetrations of renewable energy in power systems including smart grids.
- Energy storage at grid level

3. Present state and future challenges in research

A general look at research activities in universities and research centres and organizations provide an indication of activities as follows:[9-12].

- Renewable Energy
- Electrical Machines Design
- Power Electronics and control
- Electrical drives
- Power System Protection and Control

- Power Quality and EMC
- High Voltage Engineering
- De-regulation Issues
- Smart grids
- Energy Storage

There is an urgent need to rationalize the research efforts not by consolidation but cooperative efforts one or two schools concentrate their efforts is one or two areas of research based on expertise or form formal (or informal consortia).

Electrical Machines

- Electrical Machines (Design & Analysis)
- including PM or VR machines (generators/motors)
- Permanent magnet couplers, Gears and magnetic bearings.
- New topologies for Electrical Motors/Generators

Control

- Vector Control of Drive Systems (IM, PM and VR).
- Direct Torque Control
- Sensorless Control (IM, PM and VR).
- Neuro-Fuzzy Control (IM, PM and VR).

Electrical Drive Systems

- Converter Topologies for drive systems
- Soft-switching techniques
- EMC and noise issues
- Electric vehicle Applications

Energy Systems

- Power Quality / EMC.
- Power Systems Control and Protection
- Renewable Energy Engineering (wind, solar)
- Distribution/Embedded Generation
- High Voltage Engineering
- Load Forecasting
- Power Electronics in Power Systems
- Active filters
- FACTS
- Applications of superconductivity

Power Electronics

- Soft-switching techniques
- Electronic ballasts
- Converter topologies
- Power electronic control for renewable energy systems
- Grid interfacing technology for batteries/utility scale energy storage
- EV charging stations

Fuel cell and battery storage/systems development has traditionally been undertaken by chemical engineers and other physical scientists and rarely by electrical power engineers. There is certainly need to develop some research initiatives on the effects of such technologies on power systems.

- Penetration of Electricity from fuel cells/ solar and wind energy systems.
- Large Scale use of battery charging for future electrical vehicles.
- Smart/Micro Grids and distributed generation
- Smart load management techniques

Another area, which is still in its infancy, is the electricity as trading commodity on the financial markets. As electricity cannot be stored so easily as traditional commodities as products, such as metals, beverages, foods etc. There is urgent need for universities to develop short courses for business executives, future brokers and traders, investment bankers to provide some essential elements of electrical generation, transportation, distribution and utilization for business communities, through existing business studies programs or stand-alone short courses [24]. The power academic community can take this important opportunity to develop expertise in short term load forecasting, future trading in electricity, demand/supply analysis. It is an area where co-ordination/ co-operative efforts can bring larger gains for their other research activities and development.

4. Conclusions

The paper outlined the state of teaching and research in electrical power engineering. It has also highlighted the need to improve the teaching of various components of power engineering. A more aggressive approach is required to form research consortia’s and develop new and important areas. There is an urgent need to develop some initiatives in the business aspects of electricity markets. The future developments in penetration of renewable energy and distributed generation and smart grids will be a challenge to existing and traditional electrical power systems.

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Application of eLearning Course to Enhance Learning of Hydrocarbons Extraction from Unconventional Reservoirs

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Abstract: The application is based on widely-accepted standards of the European Federation for Open and Distance Learning (EFODL) recommendation. The eLearning course is accessed in mainly in asynchrony model. Some materials will be we addressed to participants using synchronic mode and in the more efficient way (e.g. streaming). The course is developed using "Moodle" software, which is accustomed to asynchrony, synchronic and streaming communication with teacher and students. The present world undergoes rapid changes and the scientific and technological advance revolutions in Natural Gas Sector. The development of new technologies is enhanced by competition, globalization, and increasing environmental imperatives. The petroleum and gas industry staff will have to be more and more professional and competent. They will have to be abreast of rapidly advancing knowledge, technologies, and novelties or be left behind. Implementation of material is an element of the standard teaching master courses (Unconventional Hydrocarbons) - developed at the AGH University of Science & Technology with EIT KIC InnoEnergy "Clean Fossil and Alternative Fuels Energy" which is open to all Polish and EIT partner universities.

Keywords: Engineering education, e-learning, online delivery, students, unconventional gas extraction

1. Introduction

The present world undergoes rapid changes and the scientific and technological advance revolutions of every aspect of our life very quickly. This tendency seems to be leading in the new XXI century (Fanchi, 2000). The development of new technologies is enhanced by competition, globalization. The petroleum and gas industry staff will have to be more and more professional and competent. They will have to be up to date with rapidly advancing knowledge, technologies, and novelties or be left behind (Fattahi.,2003, Nagy et al., 2013). Main criteria for the education of future engineers: obtainment thorough and complete knowledge on a scale of fundamental sciences likewise technologies necessity to support continuing and additional education for interdisciplinary areas; preparation of petroleum engineers to meet a new emergent discipline – energy engineering.

The new technological capabilities of shale gas production have been and still are the subject of intensive research. Future shale gas production in Europe will have strategic, economic and geopolitical implications (Siemek et al. 2009, Siemek Nagy 2012, IEA 2011, 2012, EIA, 2013). Additional issues are relevant to worldwide controversies about environmental impact of shale gas extraction (IEA, 2012, King, 2012, MIT, 2011, Siemek et al.,2013)

By the term "conventional gas" we usually define "free gas" trapped in multiple, porous zones in various naturally occurring rock formations such as carbonates, sandstones, and siltstones. The "unconventional gas" is trapped in geologic formations with very low permeability (Unconventional Gas, 2007). Reservoirs mainly contain shale gas, coal bed methane, and tight gas (see fig. 1 & 2). Other 'unconventional gas' - hydrate deposits are an additional (largest) unconventional gas resource (MIT 2011). Hydrates are structures of water/methane clathrates – usually in the moderate and deep water – and an industrial technology of extraction will probably be ready in the next twenty years.

The first three types of unconventional rocks have different properties (Unconventional Gas 2007, Shale Gas Primer 2009):

1. Tight gas – defines gas in reservoirs with low permeability (from <0.1 mD to < 0.001 mD) contained in pores with limited connections between them (no adsorption gas)
2. CBM – defines gas (methane) in coal beds, both in the free form in the cracks, as well as in the form of adsorbed (above 90 %)
3. Shale gas – defines gas in the clayey mud rocks. The primary substance constituting the organic layer generating the gas and oil is kerogen. Gas remains in the bedrock, does not migrate into other layers.

The AGH University of Science & Technology in Cracow, which accomplishes top positions in the classification of the technical colleges in East and Central Europe, conducts the two-level system of graduate study in petroleum engineering. The recruitment of students is maintained on the high educational level as for the European country, in the next year (2019) the AGH University will celebrate its 100 years of anniversary. The mining and petroleum courses have been delivered since the 1923 year. The new educational challenges are relevant to shale gas revolution.

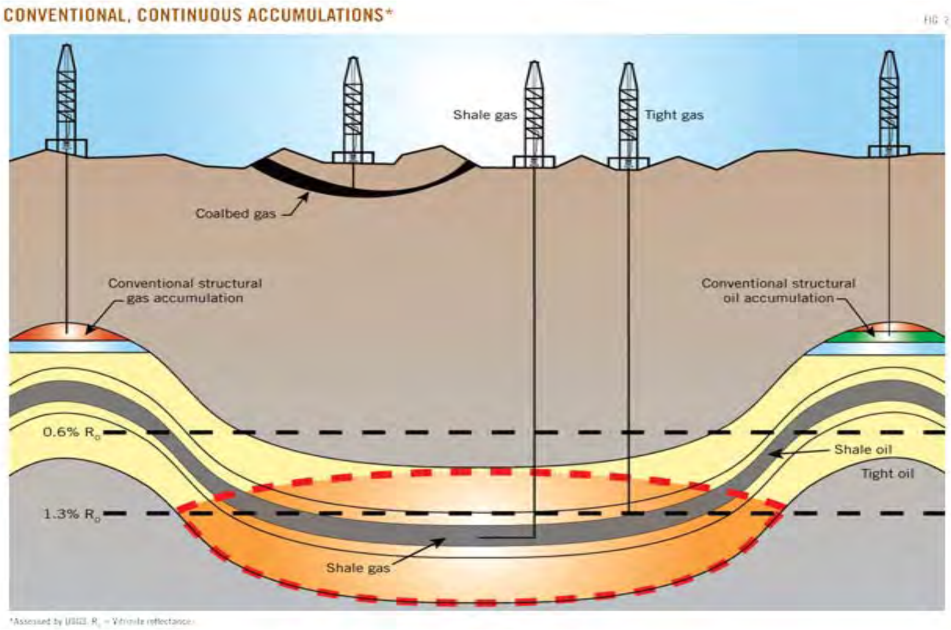

Fig. 1 Scheme of natural gas formation in unconventional and conventional reservoirs (scheme of extraction of gas using horizontal wells in shale gas deposits) (Gaswirth & Marra, 2014)

2. Method of e-learning teaching

The educational process is supported by the use of Moodle – which is a free and open-source software learning management system written in PHP and distributed under the GNU General Public License. Moodle is used for blended learning and distance education projects in various universities. The AGH University uses its slightly modified version of Moodle ver3.x. The course is developed using "Moodle" software, which is accustomed to asynchrony, synchronic and streaming communication with teacher and students. The e-learning system is available for students inside and out of university campus. The course is addressed to the students of second-degree study (master degree). Implementation of material is an element of the standard teaching master courses (Unconventional Hydrocarbons) - developed at the AGH University of Science & Technology with EIT KIC InnoEnergy "Clean Fossil and Alternative Fuels Energy" which is open to all Polish and EIT partner universities.

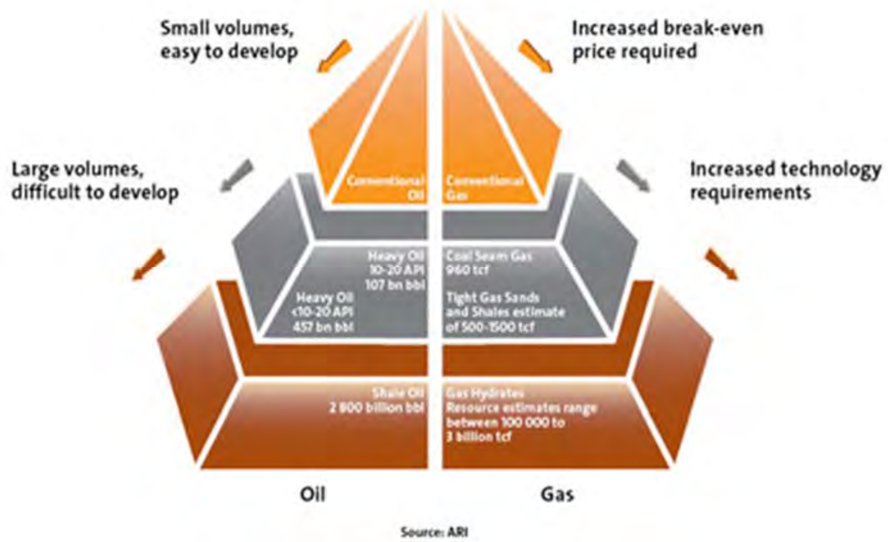

Fig. 1 Classification of natural gas & oil sources (Masters 1979, Holditch 2006, 2013)

3. Need of information and methodology of exploration and development of unconventional natural gas reservoirs

Unconventional natural gas reservoirs have specific characteristics that require advanced evaluation techniques. The proposed e-learning course the information about the geologic, geophysical, and petrophysical attributes of unconventional (shales) reservoirs. The course covers methods and workflows for identifying, characterizing, and developing shale gas reservoirs. Instruction includes examples that deliver essential key elements for understanding the exploration, appraisal, and location of production sweet spots for development (see fig. 3). Exercises demonstrate the possible economic viability of assets. The research and development of new technology in this engineering area require substantial cooperation also in the education of engineers. The progress in this technology is quick, so many of the standard educational programs have to be modified in a short time. The new teaching program assumes to create a system of e-learning training in the mixed system (conventional & distance learning).

4. Syllabus of e-learning course

Critical data used to the characterisation of shale-gas reservoirs are given in Table 1 (modified after Jenkins et al. 2008)). Proposal of preparation of e-learning course includes the following syllabus:

a. Lesson 1: GEOLOGY OF UNCONVENTIONAL OIL AND GAS RESERVOIR

   Petroleum system - the general characteristics of its components, the scheme of hydrocarbons reservoirs formation. Hydrocarbons genesis – system of natural hydrocarbons formation in oil sedimentation basin; main stages of the generation - the role of temperature and pressure. Bedrocks - types and efficiency characteristics (TOC, kerogen, Ro, generation potential). Primary and secondary migration of hydrocarbons processes and its mechanisms. Conventional reservoir rocks - classification and petrophysical characteristics. Unconventional reservoir rocks - Geological characteristic and conditions of the hydrocarbons production. Outline of the method for calculating conventional and unconventional hydrocarbons resources.

b. Lesson 2: PETROLEUM GEOCHEMISTRY;

   Organic and petroleum geochemistry. Oil and natural gas - composition, definitions, geochemical-genetic classification criteria. Bitumen and kerogen; Bedrock facies; Oil shale Geochemistry. Natural gas and oil genesis in the light of research results of molecular and isotopic composition. Hydrocarbon potential of mine coal and its relationship to the natural gas and oil. Petroleum system: from the bedrock to trap, the genetic classification of petroleum systems.

Tab. 1 Summary of critical data used to appraise shale-gas reservoirs (modified after Jenkins et al. 2008))

Analysis	Results
Gas Content	Provides volumes of desorbed gas (from coal samples placed in canisters), residual gas (from a crushed sample), and lost gas (calculated). The sum of these is the in-situ gas content of a given shale rock.
Rock-Evaluation Pyrolysis	Assesses the petroleum-generative potential and thermal maturity of organic matter in a sample. Determines the fraction of organic matter already transformed to hydrocarbons and the total amount of hydrocarbons that could be generated by thermal conversion.
Total Organic Carbon	Determines the total amount of carbon in the rock including the amount of carbon present in free hydrocarbons and the amount of kerogen.
Gas Composition	Determines the percentage of methane, carbon dioxide, nitrogen, and ethane in the desorbed gas. Used to determine gas purity and to build composite desorption isotherms.
Core Description	Visually captures coal brightness, banding, cleat spacing, mineralogy, thickness, and other factors. Provides insights about the composition, permeability, and heterogeneity
Sorption Isotherm	A relationship, at a constant temperature, describing the volume of gas that can be sorbed to a surface as a function of pressure.
Mineralogical Analyses	Determines bulk mineralogy using petrography and/or X-ray diffraction, and clay mineralogy using X-ray diffraction and/or scanning electron microscopy.
Vitrinite Reflectance	A value indicating the amount of incident light reflected by the vitrinite. This technique is a fast and inexpensive means of determining shale maturity.
Bulk Density	Relationships between bulk density and other parameters (such as ash content and gas content) can be used to establish a bulk density cut-off for counting shale thicknesses using a bulk density log.
Conventional Logs	Self-potential, gamma ray, shallow and deep resistivity, microlog, caliper, density, neutron, and sonic logs. Used to identify shales, and to determine porosity and saturation values.
Special Logs	Image logs to resolve fractures and wireline spectrometry logs to determine in-situ gas content.
Pressure-Transient Tests	Pressure buildup or injection fall-off tests to determine reservoir pressure, permeability, skin factor, and to detect fractured-reservoir behavior.
3D Seismic	Used to determine fault locations, reservoir depths, variations in thickness and lateral continuity, and shale properties.

c. Lesson 3: GEOPHYSICAL RESEARCH OF UNCONVENTIONAL RESERVOIRS;

Seismic (framework, 3D seismic, interpretation), seismic research 2D/3D: seismic vibrators 2D/3D, seismic dynamite 2D/3D, control data processing, interpretation of measurements of low-velocity zone by shallow refraction and micro profile in the hole, a complex geodetic analysis. Geophysics drilling instruments and measurement equipment. Hole measuring-interpreting apparatus type: DDL-CH/PL. Measurement methods. Plunge probes. Microseismic monitoring.

d. Lesson 4: PHYSICS AND RESERVOIR ENGINEERING

The main petrophysical parameters of reservoirs. A mathematical model of fluid filtration in porous and fractured porous media. Filtration equation of Darcy and Forchheimer - the conditions of applicability. Potential flow. Hydrodynamic conditions of reservoirs. The equation for the flow of low compressible fluid and compressible into the borehole. Mathematical methods of superposition and case studies of its applicability in the filtration process. Water influx to the wells. Physics of medium with low permeability. Thermodynamic

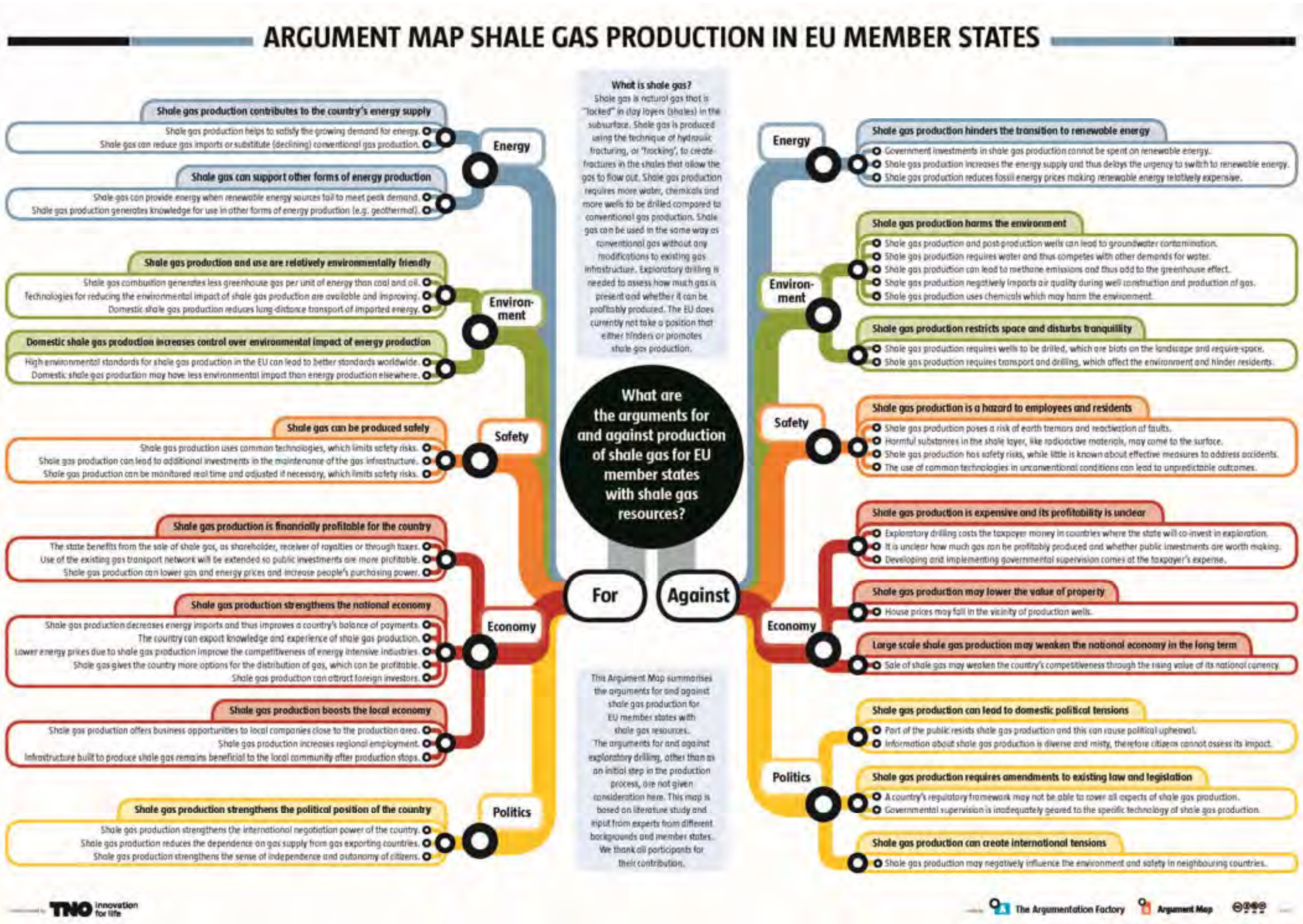

Fig. 4 Argument map shale gas production- TNO proposal for EU members (TNO, 2013)

equilibrium disturbance (pressure gradient and concentration gradient (diffusion)). Flow in micropores and pores - Navier-Stokes equation (Darcy's law). Flow in nanopores, "slide" diffusion on the nanopores walls and molecular flow.

e. Lesson 5: PVT PROPERTIES OF RESERVOIR FLUIDS

Fundamentals of thermodynamics, the definition of I, II law of thermodynamics, chemical potential, the concept of enthalpy, entropy. Properties of real gases - equations: RK, WdW, PR, nomograms h-s, specific heat, viscosity, the law of corresponding states. Fluids properties - density, viscosity, compressibility. Compression of natural gas. Joule-Thomson effect. Two-phase systems, liquid - vapor equilibrium of gas condensate and light oil multicomponent system. Recombination of reservoir fluid composition. Thermodynamic tests. Confined effects and Travalloni Peng Robinson EOS

f. Lesson 6: NEW DRILLING TECHNOLOGIES IN UNCONVENTIONAL RESERVOIRS

Directional and horizontal drilling. Directional wells profiles and notions characterizing the trajectory of the hole axis. Principles of designing trajectory axis of directional wells. Tools and deflection kits. Drilling cable used for directional drilling. Drilling technology using reel wire. Characteristics and operation of plunge engines. Perforation and fracturing in boreholes. Drilling costs.

g. Lesson 7 MONITORING AND ENVIRONMENTAL PROTECTION

The main sources of environmental threat in the exploration and exploitation of unconventional resources. Qualitative and quantitative effects of geophysical operations, drilling, completion and exploitation to environment elements. Materials and fluids toxicity. Drilling waste management (forming during shale fracturing). Waste utilization methods. Air protection, dust and toxic gases emission into the atmosphere. Noise and vibration protection. Soil and water protection (see fig.3).

h. Lesson 8 ECONOMICS OF DRILLING AND EXPLOITATION PROCESS

Rules for drawing up contracts for drilling. Economic limitations in well constructions and boreholes systems are designing. Determination of the depth of column casing is driving. Boreholes preparation to the casing and cementing. Fundamentals of drilling cost optimization for projects drilled from a single drilling site. Cost analysis of plunge equipment. Cost analysis of gas separation and transport preparation. Operating costs analysis of gas extraction, separation, and transportation.

i. Lesson 9 INTEGRATED PROJECT - PROJECT MANAGEMENT OF EXPLORATION & MANAGEMENT OF GAS RESERVOIR

Integrated project of gas production from unconventional resources. Variant risk management projects, in exploration and extraction of natural gas from unconventional reservoirs.

Verification of learning process: theoretical exam based on multi-criterion selection test. Course grades will be determined as weighed sum of following partially grades:20%: e-learning & real class participation with passing all individual homework.20%; midterm presentation related to the prepared integrated project. Each student will prepare a 15-minute presentation to the class and receive feedback; 60%: Integrated Project of shale gas production and economics.

5. Evaluation, Corrections, and Quality Management

The quality of teaching is analyzed by Kirkpatrick quality model. The most significant problem related to the teaching is: “How effective is learning process?” and “Are assumed aims realized?” The quality is checked using scheme summarized in Table 2. Following new elements in engineering teaching has been realized:

1. Possibly international networking in education and training
2. Possible finalization of pilot as Master of Science in Gas Engineering
3. Open and distance learning (flexible access, flexible progress)
1. High quality of learning
2. Active implementation of topic of course
3. Continuing revision of training courses
4. Classic and innovative techniques

Table 2. Quality workflow for e-learning course (Nagy & Siemek, 2006)

Level	name	Level description
0.A	Internal quality content course check	Content quality course reviewed by internal experts of the content of material and tool utilized in the teaching procedure.
0.B	External quality content course check	Content quality course reviewed by external - independent -experts after preparing the material of course and after finishing first test courses, by review of the table of contents, task, description of education materials and tools, etc.
I	Student's Reaction	Evaluation of course content by trained person (Student's Reaction) based upon questionnaire. The survey should include cross-section questions related to the adequateness of course assumptions, degree and value of interaction of exercises, transfer of knowledge and technology, etc
II	Learning Results	Evaluation of course content by adequately prepared and analyzed test system. By test suites - start tests/final test - it is a reasonable evaluation of increase of competitive, knowledge, skills related to present training. The analysis of a large number of system tests may acquire date to an estimate of weakness points of course.
I sII	Behavior in the Workplace	Evaluation behavior of trained person in the workplace after 3-6 month after finishing the course. The assessment grade is possible using prepared "critical - course" specified elements of the behavior of trained person.
I	Final results	Evaluation of quality of course based upon specific data related to quality of work of trained person (effectiveness of work index)

6. Conclusion

A new e-learning training approach based on a modified classroom situation plus self-study will be established, which will have excellent characteristics of teaching. A new possibility to build an international networking educational model can be implemented – on demand. The proposed e-learning system can be extended in future by implementing the virtual laboratories related to natural gas engineering.

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Impact of Shale Gas Exploration Process on Environment in Poland

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Abstract: This paper is a summary of the results of environmental analyses within the monitoring of the process of natural gas exploration in unconventional reservoirs. Particular attention was drawn to the analysis of the physicochemical condition of post-reaction fluids, soil gas in the well pad area and drilling fluids. The results of studies reveal that prospecting works do not create a significant environmental hazard. Some indices connected, e.g. with the noise climate lightly exceeded permissible values. The research did not show any adverse impact of the prospecting works on the chemical condition of groundwater and surface water in the observed time horizon. Nonetheless, if extensive exploration and production of shale gas are involved, the environmental studies need additional work. The groundwater was not contaminated due to the performed enhancement jobs. No indirect impact has been observed in Poland yet, e.g. changes in surface/groundwater levels or flow rates, permanent contamination of air with gases or dust, etc. Hydraulic fracturing, in particular, in exploration wells does not induce (in Polish conditions) seismic tremors that would be perceptible on the surface. The studies conducted in Poland were the first field research works in Europe made in the context of unconventional hydrocarbon prospection and exploration with the borehole method on such a large scale. The discussed outcomes from research project have been prepared on the basis real drilling and fracturing done in Poland in years 2011-2014.

Keywords: shale gas, environmental protection, gas engineering, fracturing, Poland

1. Introduction

Natural gas and oil trapped in ultra-low permeability shale rocks are significant hydrocarbon resources. This low permeability of rock causes marginal productivity in vertical wells and to increase or capacity of gas from wells the horizontal well drilling with the multistage stimulation process is standard (after 2007) proposed. During horizontal section drilling, the drill bit is steered from its downward trajectory to follow a horizontal path for 1-2 km or more to thereby exposing the reservoir/wellbore surface to as much as possible. The system of artificial fractures provides the permeability for gas to flow, open existing naturally micro fracturing network, but the contribution of overall gas capacity is related to the matrix permeability.

The potential and real impact of extraction process on the natural environment and human health have been a subject of several discussions in USA and Europe for last years (MIT, 2011, King, 2012). The hot discussion about the fracking process in the USA started after the presentation of a film „GASLAND" (directed J. Fox) in 2010, and after a series of green papers in local newspapers, lectures in the eastern U.S. states, (e.g. Pennsylvania, West Virginia and Ohio) in the last ten years. One of the results of the public discussion, is a prohibition of shale gas fracturing in Vermont (2012), Maryland

(2015), New York (2015), Washington D.C., within cities of some states (e.g. Colorado, Texas), and some counties in California, New Mexico, Ohio.

The injection of waste water into the reservoir - relevant to shale gas production is very popular in the southern states (e.g. More than 2000 wells in Texas State), but in several states have been banned due to the increased number of micro-earthquakes linked with drilling waste injection (see Arkansas, Massachusetts, New Jersey). Time banning moratoria for fracturing process exists or existed in the various states (e.g. France, Bulgaria, Luxemburg, The Netherlands) and some regions of Canada (Quebec Province), Spain, UK (Scotland and Wales). All real and hypothetical environmental impacts of the natural gas extraction process have been broadly discussed in the public media and scientific society. The first incomplete summary of the discussion can be found in several reports: EPA presents MIT (2011), King (2012), IEA (2012), EPA (2012) and the most sophisticated report in the 2015 year. These reports discuss the effect of drilling activity on the environment and industrial gas production. During the 2010 year, gas production from unconventional reservoirs (shale rocks, tight rocks, and CBM) reached in the USA 200 Bcm (which is 28% of total gas production in this year) (IEA 2015, EIA 2011, EIA 2013). In the 2014 year, the total gas production in the USA achieved 687 Bcm, out of which shale gas production exceeded 54% (see Figs. 1).

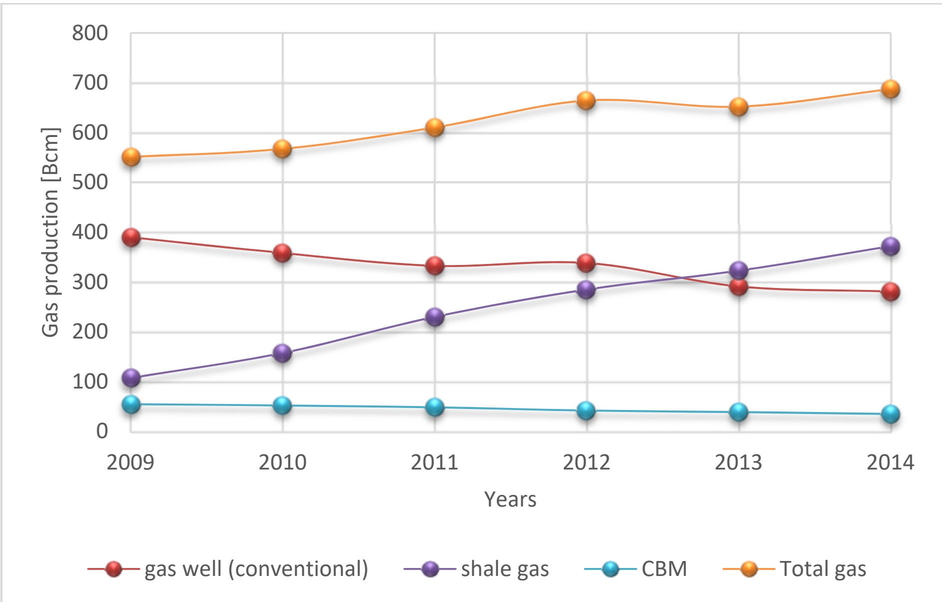

Fig. 1 Natural gas production (in the USA) in years 2009-2014 (Bcm)(after IEA 2015)

2. Exploration process in Poland, environmental impact

The large-scale research process for shale gas in Poland started in 2010; first seismic profiling, analysis of archival geological data, and finally through drilling. In the years 2010 – 2014 over 100 companies were engaged in exploration on 101 concession areas (2011). The negative opinion about the gas extraction impact on the environment has been published in the EU with the ENVI report (2011). This publication sparked the need for new research on the impact of technology on the environment. The research on the influence of drilling and fracture works and extraction on the natural environment has been ordered by the Director General of the Environmental Protection (Poland) and realized by Polish Geological Institute (PGI-NRI), AGH University of Science & Technology (AGH) and University of Technology in Gdańsk (UTG) in the years 2012-2014.

The research areas were localized around wells in which geological prospecting works were performed by seven zones located within the Wejherowo, Elbląg, Stara Kiszewa, Lębork, Bytów, Wierzbica and Zwierzyniec concession areas. Five of these test locations was localized in the northern part of Poland (in the Pomerania province), and two of them in the SE part (in the Lublin area) (see Fig. 2). The geological conditions in Poland are different; gas shale reservoirs are located in deeper horizons, which may imply that environmental problems with aquifer pollution are just of a theoretical. The goal of the research was founding the actual impact of natural gas exploration process on the environment: atmospheric air, noise, land surface (including its transformation resulting in landscape changes, i.e. vibrations and seismic tremors that may affect the existing infrastructure and stability of morphological elements), grounds and soils and their mechanical properties, organic matter content and biophilic substances and potential contamination and surface waters and groundwater (see Table 1). The necessary research was relevant to evaluate of hazards related to the fracturing activity of surface and ground waters.

Tab. 1 Research done by governmental agencies (in real conditions).

		USA	Poland*
1	Water acquisition	x	x
2	Water composition (background)	x	x
3	Flowback chemistry	x	x
4	Seismicity & earthquakes	x	x
5	Acoustic climate	x	x
6	Wellbore integrity	x	x
7	Soil protection	x	x
8	Drilling cuts management	x	x
9	Wastewater reuse	x	
10	Surface water protection	x	x
11	Drinking water aquifer protection (methane pollution?)	x	x
12	Drinking water aquifer protection (chemical pollution)	x	x
13	Methane (e.g. co2) emission	x	x
14	Direct impact on human health	x	x

* Only for exploration (early & late stage)

Field works were preceded by a detailed analysis of geological and hydrogeological conditions of particular research areas, taking into account the degree of confinement of potential reservoir rocks. An important task was the identification of possible migration pathways fluids to fresh groundwater horizons and land surface. The research has been covered in following tasks:

1. identification of the local conditions and field studies planning,
2. examination of the baseline status of the environment,
3. studies while drilling vertical/directional wells,
4. studies during hydraulic fracture stimulation and gas flow testing,
5. examination of the status of the environment on completion of drill site operations,
6. monitoring of the status of the environment after the completion of downhole operations.

The full environmental test cycle was performed only in some of the research areas (see e.g. tab 2). However, the condition of particular environmental elements at the beginning of the study was determined for all of them as a reference for possible changes during successive stages (Konieczyńska et al. 2015).

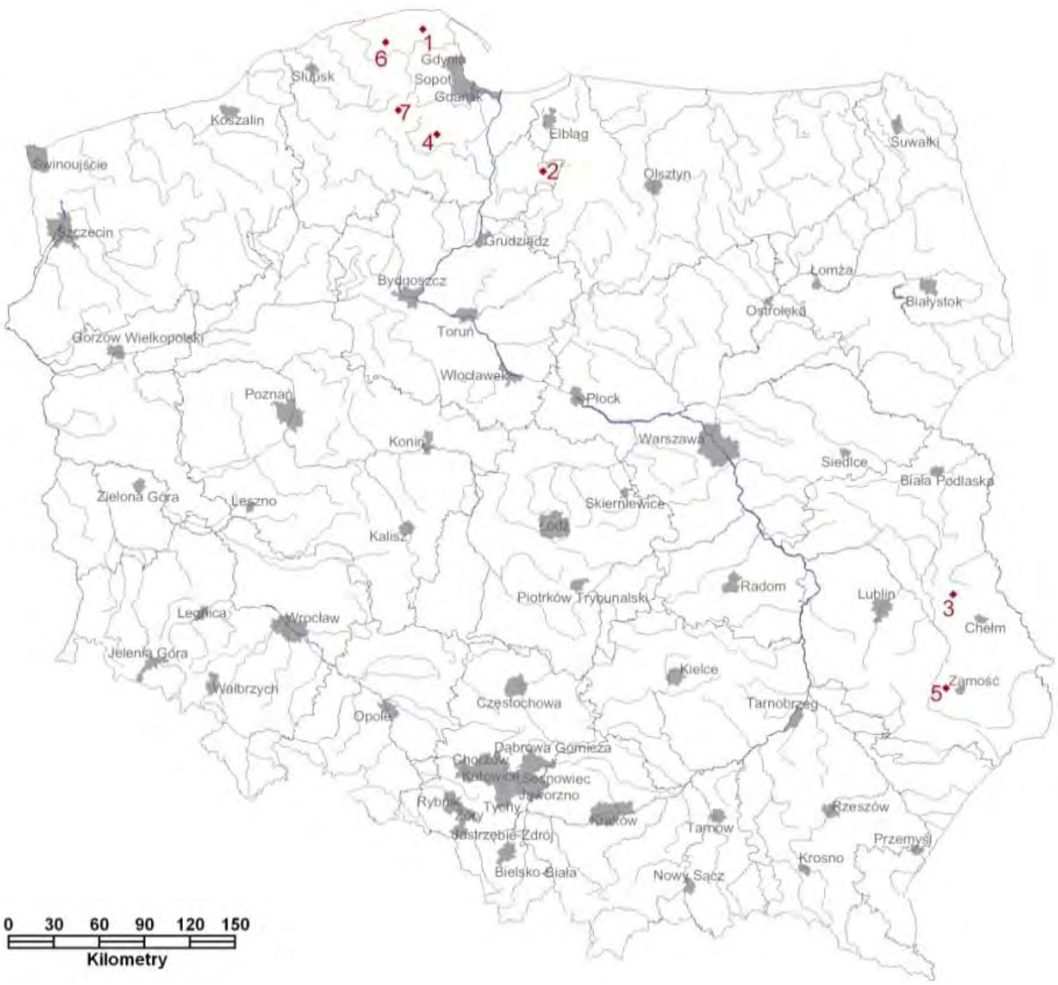

Fig. 2. Test Sites Localization (Raport- wyniki badań środowiska…, 2015)

Tab. 2. Surface Water & Groundwater survey of test sites (Raport- wyniki badań środowiska…, 2015)

Test site	Surveyed area- Estimated size in km²	Number of groundwater monitoring sites	A number of surface water monitoring sites
Lubocino	12.5	14	5
Stare Miasto	78.5	17	4
Syczyn	78.5	28	-
Wysin	28.0	16	2
Zawada	78.5	15	2
Łebień	39.2	9	1
Gapowo	28.0	16	1

Tab.3 Average values of the flow back compositions (Raport- wyniki badań środowiska…, 2015)

Test site		Lubocino		Stare Miasto			Syczyn		
Aquifer		TA		TA			TA=MCA		
Index	Unit	Stage I	Stage II	Stage I	Stage II	Stage III	Stage I	Stage II	Stage III
		Average		Average			Average		
pH	-	7.38	7.6	7.14	6.97	7.11	7.31	7.27	7.25
SEC	µS/cm	323.7	262	988	802	863	771	830	657
Na	mg\dm3	8.73	4.28	15.94	11.1	12.96	23.57	28.62	9.72
K		5.92	2.63	52.12	2.2	49	24.45	38.63	22.3
Ca		51.75	45.00	132.54	139.8	127.8	105.85	107.35	110
Cl		8.82	6.88	24.62	24.62	16.87	33.77	33.22	14.2
Sr		0.09	0.07	0.74	0.34	0.58	0.85	0.77	1.44
Br		nc	nc	nc	nc	nc	nc	nc	nc
B		0.0175	0.0125	0.09	0.07	0.09	0.09	0.14	0.06
Li		0.00071	0.00076	0.0129	0.0074	0.0118	0.0079	0.0065	0.0138
Phenolic index *		0.01383	0.11375	nc	nc	0.093	nc	0.01828	0.1295
Oil index		0.0542	0.347	0.0667	0.02563	0.0108	0.0387	0.0306	nc
Anionic detergents		0.260	0.160	0.367	0.92	0.1375	0.3655	0.3155	0.2575
methane		0.00060	0.00105	0.03621	0.00143	0.00385	0.0035	0.0014	0.0021

nt – not tested (no fracture stimulation at Wysin site),
nc –not calculated (over 50% below the determination limit),
* - low credibility results (further testing required)

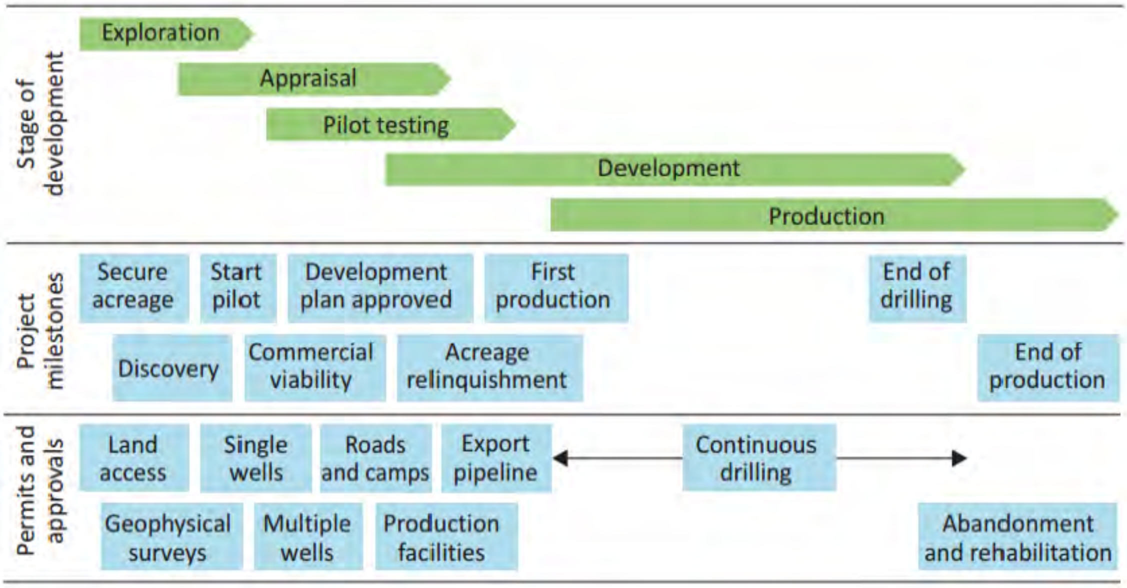

Fig. 3 Sequences in the development of the extraction of shale gas (IEA, 2012)

3. Results of environmental study in shale gas exploration zones

During successive stages of research, the subsequent measurements and observations were performed: traffic intensity of vehicles, noise emission during drilling and fracturing, dust emission, volatile compounds and gas emission. Furthermore, the balance of water and chemical substances used for technological fluids, especially fracturing fluids, has been checked. Analytical samples were collected, and the chemical composition of drilling waste, fracturing and flowback fluids and composition of produced gases were analyzed (see tab.3). Information about the amount of flowback and produced water, the amount of generating waste and its management methods was also gathered. After each technological stage (preparation of the well pad, drilling of wells, hydraulic fracturing, production tests, liquidation of the wells and site restoration) marker tests were performed to check the status of the environment (Badania aspektów środowiskowych…, 2011). Based on the geological and hydrogeological conditions analysis, a long-term environmental monitoring program has been established. Potential changes have been observed in a relatively long time perspective. Long-term follow-up measurements have been done in three research areas, i.e. Łebień – 2.5 years, Syczyn - 1 year and Stare Miasto – 1.5 years after finishing hydraulic fracturing jobs in exploration wells (Macuda, 2012). Some conclusions about the scope of the environmental impact of the drilling process and fracturing of shales were drawn from the performed measurements and analyses in next stages of development (fig.3). Perspective shale formations are deposited at great depth and are covered by the sealing caprock, which is important in the context of potential migration of flowback or produced fluids towards potable aquifers. The series of low porosity and permeability rocks in the caprock and the lack of conductive/transmissive fault areas protect aquifers (Siemek and al, 2013).

4. Conclusion

The research did not show adverse effects of the exploration drilling process on the chemical condition of groundwater and surface water in the observed time of research. The quality of local aquifers and hydrocarbon concentration in the soil gas in the area of drilling should be monitored because reservoir fluids could potentially migrate, e.g. through the cemented annular spaces along the casing (losing its tightness with time). The gained results specify that failures or rough operation in the rig area may lead to the penetration of some substances from the surface to shallow groundwater. The observed cases do not have an extensive character, and the efficiently operating control system and accurate monitoring should help to identify the risks. Hydraulic fracturing, in particular, in exploration wells does not induce (in Polish conditions) seismic earthquakes that would be perceptible on the surface. So far registered tremors have not exceeded the acceptable levels, according to the Polish standard PN-85/B-02170.

Chemical analyses reveal that used drilling mud and drilling cuttings from the exploration wells may create a risk for living organisms in case they uncontrollably get into the environment. The studies conducted by research consortium PGI-AGH-GTU were the first field research works in Europe made in the context of shale gas exploration method. The results show that the hydraulic fracturing in horizontal wells did not have any significant impact on the natural environment. Care should be paid to the fact that the environmental impact of such investments depends on the type of activity, their intensity, technology and measures implemented for minimizing adverse environmental effects. Unlike previous European research projects, which were based only on estimations and data extrapolated from the USA and Canada, the mentioned research one (Macuda & Konieczynska 2015, Konieczyńska et al., 2016) has been prepared on the basis real drilling and fracturing done in Poland in years 2012-2014.

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Use of Virtual and Remote Laboratories: Opportunities for Fluid Mechanics Subject in Western Sydney University

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Abstract: The evolution of digital computers along with the advancement of simulation technology, remote controlling of instruments, automated data acquisition and rapid data analysis methods have opened a new door of delivering engineering education via online and blended learning. The distance delivery of engineering degrees often needs use of virtual and remote laboratories in order to facilitate online teaching of laboratory components of an engineering degree. Remote laboratory presents an opportunity for a student to complete the required laboratory components of his/her degree usually from a distant location, and more importantly at his/her convenient time. In virtual laboratory, the experimentation is performed by controlling the laboratory equipment using web-based means. This paper presents the state of the art of recent research and developments on online learning via virtual and remote laboratories. This in particular makes a comparison among three different types of laboratories, hands-on/physical, virtual and remote laboratories. Finally, the opportunities and limitations of a proposed virtual/remote laboratory for Fluid Mechanics subject in Western Sydney University are explored.

Keywords: Virtual laboratory, remote laboratory, distance learning, online experimentation, simulation, engineering education, blended learning

1. Introduction

An engineering degree generally embodies a significant laboratory component. Laboratory allows students to improve their understanding of the theoretical knowledge gained during lectures and reading of other learning materials such as text book and lecture notes. There are numerous online means to enhance theoretical knowledge in a given engineering subject. However, the necessary practical knowledge can be achieved via laboratory. Feisel and Rosa (2005) discussed three different types of hands-on/real laboratories. This includes development laboratory, which focuses on design, development and determination of performance in relation to a given set of specifications for a given project. Another type is research laboratory, which is used to test new research hypotheses or improve a current industrial practice. The third type is educational laboratory where the classroom theoretical knowledge is applied to improve practical experience of students. It is an established fact that practical experimentation in the laboratory plays a significant role in engineering education. According to Nersessian (1991), hands-on or practical experience is the heart of science education. Clough (2002) stated “laboratory experiences make science come alive”. Therefore, the importance of laboratory experimentation for engineering students is irrefutable regardless of the objective, e.g. design, research or education.

Despite the important role of practical training of students in science and engineering education, teachers face various problems, which include limitation of laboratory resources due to high cost of equipment, prescribed/limited time allotted to a student to perform experimentations. Therefore, provision of appropriate, meaningful and sufficient laboratory experimentations for students remains a critical component in engineering education as discussed by Tiernan (2010). More recently, online education is making its way with a considerable pace in order to meet the increasing demand of students who cannot attend the regular university courses due to work and other commitments.

It is comparatively easy to provide theoretical knowledge in engineering subjects via online means; however, providing practical/laboratory experience to students has always been a challenge in distance learning methods. An e-learning solution to this problem is possible via development of web-based experimentation using today's high speed internet technology (Macedo-Rouet et al., 2009). Virtual/simulation laboratory environment, remote controlling of laboratory equipment, automated data acquisition - all of these provide a new opportunity for online delivery of laboratory components in engineering education. Controlling instruments remotely is increasing with the rapid improvement of communication technologies.

Virtual laboratory can be used when the laboratory equipment is too expensive, unavailable or the experimental procedure is unsafe. One of the most important features of virtual laboratory is the non-destructive nature of an experiment; for example, a student can learn from his/her failure without any damage to the instrument involved. According to ABET, learning from failure is one of the nine important aspects of engineering education. Virtual laboratory involves different software like LabVIEW, MATLAB/Simulink, ANSYS, Java Applet, and Flash, which enable simulation of laboratory environment. Remote laboratory may be defined as the experimental procedure where the laboratory instruments are controlled from a distant location. Remote laboratory may be suitable for the cases where number of enrolled students in a subject is too high and also when there is a limitation in the availability of certain laboratory equipment (Chen et al, 2010).

Ma and Nickerson (2006) presented a comparative study on hands-on, virtual and remote laboratories. Virtual laboratories were defined as the 'replications of real experiments' where the structure required for experiments are not real, rather simulated by computer software. They defined remote labs as the 'mediation of reality', which is similar to real or hands-on laboratory since they also require real laboratory equipment as well as space. The main characteristic which distinguishes remote labs from hands-on laboratory is the distance of the laboratory equipment and the person carrying out the experiment. In real or hands-on laboratory, the equipment may be controlled using a computer; however, in remote laboratory, the experimenter is located geographically at a certain distance from the experimental facility.

Types of virtual and remote laboratory systems as well as the outcomes of the adopted system vary across different institutions. This paper highlights the recent literatures, especially the comparative assessment of different types of laboratories used by engineering education providers and how well they meet students' learning objectives.

2. Remote and virtual laboratory system used in different institutions

In engineering education, the application of remote laboratories depends on the flexibility, cost and effectiveness of the system. The idea of remote laboratories first came when internet technology started during 1970s. Since 1970s, different online learning programs have been developed and applied by educational institutions such as PROLEARN, MIT OpenCourseWare (Gomes & Zubía, 2008 and Gustavsson et al., 2009). Recent developments in the field of remote laboratory include LabVIEW, which is based on all three different laboratory types: remote, virtual and hands-on (Abdulwahed, 2013). LabVIEW is designed to allow multi user access for the experimentation. A brief discussion is given below for some of the most well-known remote laboratory systems.

a) WebLab-Deusto: This is an open source remote laboratory system, which was designed mainly for the students of University of Deusto. It was first launched in February 2005, with the main objective of supporting the laboratory experiments for engineering subjects. The platform used for this system is Client to Server architecture software. It enabled the students to perform real laboratory experiments e.g. CPLD, PIC microcontrollers and FPGA from a distant location via computer network (Orduña, 2011).
b) UTS Remote Labs: The remote laboratory used in University of Technology Sydney (UTS) is a part of LabShare system, which is funded by Australian government. The objective of this system is to make a national network of laboratories, which can be accessed remotely. Like WebLab-Deusto, this system also uses a platform of Client-Server architecture.
c) iCampus iLabs: This system is used in Massachusetts Institute of Technology (MIT), which is based on a distributed software system and a middleware based infrastructure. This supports the laboratory access via internet for sharing among different educational institutions worldwide (Harward et al., 2008). The platform is same as in the previous two, i.e. Browser to Server architecture software.
d) Virtual and Remote Laboratory (VR-Lab): This system of remote laboratory has been developed by Texas Southern University (TSU) with the collaboration of University of Houston (UH). To use this remote laboratory, there is no need to install an extra plug-in in the browsers. The platform is based on Browser-Server architecture software. This was designed to carry out the experiments of data communication system and digital signal processing.
e) LiLa (Library of Labs): LiLa was developed in collaboration by eight different European Universities and three business organisations. The objective of this remote laboratory system is to provide a common platform for the mutual exchange of laboratory facilities among European institutions, especially for the students of undergraduate engineering schools (Mateos, 2012). LiLa fulfils the purposes for both remote and virtual laboratories. In case of remote laboratory system, plug-in for the browsers needs to be installed in the users' computes in order to gain access the laboratory equipment. The platform is Browser-Server architecture.

Examples of some of the widely used systems of virtual laboratory adopted by engineering educational institutions are given below.

a) Flash: There is no need for browser compatibility issue for this platform. With only plug-in, Flash files can be viewed via internet. It has been widely used by many different engineering schools around the world. For example, University of Delaware has developed a virtual microscopy using Flash (Barrett et al., 2009).
b) Java: Java has been used by Chen et al. (2008) to create a virtual laboratory system for teaching the resistor colour code. The clients can use the combo box to select different combinations of colour bands in this model. The result is then calculated by the Java applet. Java has been adopted in many other remote and virtual laboratories.
c) Matlab/Simulink: This software is used in most engineering universities today to carry out simulation and modelling of different engineering problems. This is also widely used for research purposes. For example, Schmid (2001) has presented a virtual laboratory using Matlab/Simulink using virtual reality. Casini et al. (2001) developed an Automatic Control Telelab (ACT) using Java servlet and Matlab/Simulink.
d) LabVIEW: This commercial software is developed by National Instruments. It is popular

software used by many universities and educational institutions. In addition to the applications for virtual labs, this is also widely used in remote laboratory system.

e) ANSYS Fluent: This software has a strong platform for physical modelling of fluid flow, heat transfer, turbulence behaviour of fluid, furnace combustion and many other applications ranging from bio-fluid simulation (e.g. blood flow) to semiconductor physics and wastewater treatment plant modelling to clean room. It is widely used for simulating engineering problems related to computational fluid dynamics (www.ansys.com).

3. Application of virtual and remote laboratories in Robotics

Some of the first successful projects of remotely driven industrial robotic components were the Telegarden Project (Goldberg et al., 2000), Mercury project (Goldberg et al., 2000) and the remote laboratory developed at the University of Western Australia (Taylor & Dalton, 2000). These systems were developed to enable the students to move the robot and operate the objects in the workspace via internet. These internet based remote laboratories opened a new trail for robotics e-learning during the past few years. Among the widely used remote and virtual laboratory platforms used for robotics these days, four important ones include ARITI project (ARITI, 2000), the UJI Robot (Marín et al. 2003), RLab (Safaric et al. 2001) and Robolab (Candelas et al. 2005). Students can control a Cartesian robot using ARITI's telerobotic features, which consists of an interface based on amplified reality. UJI Robot, having a multirobot architecture system, allows the users to access both industrial and educational robots through internet. In addition to this, the robot arm can be controlled by using an amplified reality. RLab is a combination of internet based prototype laboratories for Engineering Robotics subjects. It provides the users with online access to real hardware for remote control of the robotic components. Robolab is an open platform used for simulation and controlling of robotic arms via internet. The main limitation of these systems is that they can only be used for reaching the kinematics of robots. The control of the dynamics and programming issues related to many subjects of robotics and automation is absent in these systems. Casini et al. (2008) discussed another successful virtual and remote laboratory system for Robotics and Computer Vision fields: RACT. RobUALab is a complete software platform for simulation, teleoperation and programming of a robotic plant (Jara et al., 2010). Using this platform, the clients can perform experiments with different concepts about Robotics and Automation such as kinematics, dynamics and path planning of a robot manipulator. In addition, the programming of different components of the robot can also be carried out using this package.

4. Learning outcome from hands-on, remote and virtual laboratories

In recent studies, it has been found that in fewer literatures (less than 70%) published before 2002 results were in favour of e-learning in engineering education. This statistics increased to 84% studies after 2003 (Shachar & Neumann, 2010). In most cases, the outcome is dependent on the prior knowledge of the students. Simulation of abstract concept increases the conceptual learning in cases where the underlying mechanism of the problem is comparatively simpler. This applies only with the students having low prior knowledge. Students with higher prior knowledge benefitted more from the simulation of a problem having a complex underlying mechanism (Olympiou et al., 2008). Colorado Department of Higher Education (2012) carried out a study to find out the effectiveness of three different types of laboratories. It was shown in this study that students who completed with non-traditional learning system (virtual and remote) achieved slightly lower grades than the students who completed their study in traditional learning system. After the completion of virtual laboratory experiments, the students were engaged in face-to-face laboratory experimentation. It was found that they performed better than those who already carried out the experiment in a hands-on laboratory (NRC, 2006). In some cases, the virtual and remote laboratories are more effective than hands-on laboratory having sufficient time for experimentation. Education providers can design the delivery system of practical lessons by taking the advantages of the affordability of these laboratories. Ensuring the highest benefit from the designed instruction of laboratories is the most crucial variable in determining the success of engineering education (De Jong et al., 2013).

5. Possible applications of remote laboratory in the fluid mechanics subject of Western Sydney University

Western Sydney University (WSU) is encouraging a blended learning approach in offering engineering course. Blended learning is a concept that utilizes the best aspect of face to face and online delivery methods. In order to make the engineering course fully online, one of the main problems that is being encountered by the students and teachers of WSU is the laboratory component of the course. Fluid Mechanics is the core subject for both Mechanical and Civil Engineering undergraduate students in WSU. Blended learning has been applied to Fluid Mechanics by Rahman and Al-Amin (2014). In this study, the tutorials in Fluid Mechanics were uploaded to 'YouTube', lectures were recorded and posted to the website, and online practice quizzes were introduced. In another study by Rahman (2016), it has been found that this blended learning increased the satisfaction level of the enrolled students and improved the learning outcomes overall. As a part of the future enhancement of this subject, the virtual and remote laboratory facilities should be incorporated with the current learning materials.

Two of the most important experiments of Fluid Mechanics are (i) demonstration of Bernoulli's principle and (ii) analysis of pipe friction. The experimental setup of these two experiments is shown in Figure 1. Dai et al. (2010) have shown the application of virtual and remote laboratory system in three different laboratory experiments of fluid mechanics. In this study, values of pressure have been considered as the output of the experiments. The remote laboratory consists of a server, client and control side interface and the virtual laboratory consists of 3D model of experimental setup, input parameters and output results.

(i)

(ii)

Figure 1: Experimental setup of demonstrating (i) Bernoulli's principle and (ii) pipe friction

The commercially available laboratory setup has been retrofitted with the networking system and the control devices in order to develop the remote laboratory. This enabled the students to perform the laboratory experiments from anywhere via internet. Customized software was developed using Visual C++ to create the virtual laboratory.

At Western Sydney University (WSU), these two experiments mentioned above can be incorporated with virtual system using commercially available simulation software such as ANSYS Fluent, SimScale and NEi Nastran. For remote laboratory, the diameter of the tubes used in the experimental can be obtained from pre calculated values since they are fixed. The flow rate can be controlled by a solenoid valve wired to a power supply. It may be noted that the solenoid valve position or the current flowing through it needs calibration for flow measurement. The pressure gauge reading is converted to a current reading. The computer can receive data from a web connected multimeter. A data logger can be used for control and data acquisition, which is connected to the computer. The liquid level sensor, which in turn transmits a current or resistance reading to the computer, gives the volume of water collected in a given time. The manometer reading as well as a visual access to the experiment can be obtained by using a wireless network camera. This camera should have sufficient optical zoom and autofocus technology. The remote users should be able to control the camera position via a web interface. The above procedure will allow WSU Fluid Mechanics laboratories to be accessible to the enrolled students (about 250 students in a year) remotely.

6. Conclusion

Recent advancement in e-technology has opened many new opportunities in the field of virtual and remote laboratories. More recently, many big universities are adopting online education method for numerous courses. In case of engineering courses, laboratory component has been regarded as main obstacle in online delivery; however, virtual and remote laboratories can provide a solution to this problem. Furthermore, it is possible to improve the learning outcomes of the on-campus students by combining physical, virtual and remote laboratories. With the increase in number of students and having limited laboratory equipment facility, education providers are showing interest towards virtual and remote laboratories. This paper has presented a methodology to develop virtual/remote laboratories in the Fluid Mechanics subject in Western Sydney University; however, it needs further investigation, and possibly a pilot project to make this a reality.

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Persuasive Industrial Design and Human Computer Interaction in Child Development for Sustainable Behaviour and Water Conservation

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Abstract: This article narrates on work in progress relating to influencing sustainability awareness and knowledge with subsequent change in behavior from childhood. The project was based on CDIO (conceiving, designing, implementing, operating) syllabus, industrial design and human computer interaction. The study focuses on issues of water conservation as a resource said to become premium commodity in near future and its scarcity in our country. Background information and literature review supports the view sustainability goals require more than efficient planning, strategy, implementation and regulation. Importantly, behavioral change through persuasion becomes pivotal to enable a generational cultural transformation relating to sustainability and wellbeing. Researchers found behavioral formation and change happens preferably through daily familiar practice rather than regulatory or financial penalty, as with water bills. One such instance, is the daily ritual of bathing where parents/guardians and children connect with each other through a task and also allows for a child to increase experiential learning through play based on project-based learning. Project findings based on conceiving-designing-implementing-operating framework are leading to a working minimum value product (MVP) and system solution closer to its next stage of deployment with a subgroup of possible customers or early adopters.

Keywords: CDIO syllabus, Project-based learning, Human-Centred Design, Water Sustainability

1. Introduction

This article narrates on work in progress relating to how industrial design and human computer interaction can influence and increase sustainability awareness and knowledge with subsequent change in behavior from childhood. The project demonstrates a new school's industrial design education approach that pursues new product development (NPD) and innovation based on a conceiving-designing-implementing-operating framework. That differentiates from traditional design education that thought products as successful while they were only developed to a conceiving level. In contrast, the new framework and specific project move forward from last century discipline tradition helped by design research through and by design (Cross 2001). The latter redefines the design problem as a wicked one that cannot be just formula about product production. Instead, it progresses through contextual inquiry, research on activity, cognition and resources, iteration process to diminish failure, and co-designing successful solutions together with users to satisfy purpose, enhance experience and interaction, and enrich behaviour and meaning. All three drivers in this project, CDIO syllabus, design research and sustainability find common ground in design education when coinciding with 4 pillars of learning promoted by UNESCO as learning to know, to do, to live together and to be (Delors et. al. 1996)

Drinking quality water is a highly valued resource since it is difficult to find alternate sources for it besides rain water. Water management and usage improvements are increasingly becoming high priority in Australia because the country's naturally dry climate and low annual rainfall. Water conservation is critical in times of drought and water shortage. Its preservation is affected by day to day usage and household activities in times of abundance as well. It is said there is the need for a cultural shift concerning resources and consumption in order to implement a more sustainable planet that is challenged by conflicting realities of natural and human environments, chains and flows of organic, inorganic and human made complex systems. Behavioural change is becoming a priority when resources are diminishing while human population keeps increasing at exponential rhythm. However, that modification is not easy task since people tend to replicate old habits by inertia, tradition and peer influence. It is naturally simpler to carry on with patterns of conduct learnt and supported by infrastructure that facilitates consumption, signifies straightforward use while lacking means for awareness on effects of that use and control of that utilisation.

Awareness of climate change currently proves not enough to drive people to change behaviour and take action. Eco-feedback technologies generally provide information to users on up-to-date resource usage. This has shown to improve sustainability and conservation efforts in the home environment. However, eco-feedback is mostly handled by adults and requires dedication and attention for it to work. As with other technologies, lack of persistence and follow-through habits often mean they are no longer used after a while. One way to approach the challenge is through persuasive technologies centred on project-based tasks from the outset that mould habit and support generational change as in the case of teaching children about water sustainability through practice and experience. By definition, persuasive methods have proven to be successful in changing attitude and behaviour patterns by enhancing and promoting positive change in different fields.

2. Problem Statement

Challenges relating to water and basic amenities (e.g. lighting, sewage, transport) were significative until the first half of the last century in western societies in modern history. Since then, developed countries experienced incremental affluence in the last two or three generations. With that, challenges such as water supply have become taken for granted. However, today water management and usage are becoming again pivotal to everyday life because of resource scarcity and population density as people are increasingly gravitating towards urban centres, soon to transform into mega-cities. While people move and adopt urban life they bring with them expectations of modern life and also habits inherited after two or three generations that have not experienced water scarcity.

The current challenge is how to enhance and change behaviour through persuasion to a point that water consumption is improved and people experience a sustainable generational change that allows for effective eco-systems and growth. Therefore, this research intends to contribute to sorting out that challenge by developing a conceptual model that comprises systemic and product solutions with intuitive affordance, easily enhance and augment established behaviour, familiar emotions and ties. Specifically, attention is focused to the ritual of bathing as an instance where adults and children can turn project-based tasks into experience and emotion as pillar for new affective and persuasive sustainable practice.

Research to date has intended to answer the following main research and additional auxiliary questions:

- How children aged 3-5 can learn sustainable water practices through implementation of persuasive and eco-feedback technology in the home environment?
    1. What household areas have the highest water usage, and the most chance for conservation?
    2. What are the benefits of effective resource management and the implementation of sustainable techniques?
    3. How do young children learn, and how can this be implemented in potential design solutions?

4. How can teaching young children sustainable practices benefit the world into the future?

3. Background

Background and literature review findings facilitated a good grounding for this research in areas of water usage and consumption, children learning and persuasive technologies as per succinct extract following. Australia according to Australian Bureau of Statistics (2007), is fortunate with 97% of the population connected to water mains in towns. Household water usage breakdown is similar through the country. On average they saved "67% of water in the bathroom, 64% in the laundry, 50% in the kitchen and 40% in the toilet." Meanwhile, research by Willis, Rachelle M. et al. (2010) on the QLD Gold Coast categorized water usage representatively (Fig 1). Water conservation has been a significant focus for some time, due to droughts, which have in turn increased people's awareness of water conservation. Since March 2008, 75% of Australians have been affected by water restrictions (Grafton & Ward 2008) that are still implemented today as 'Water Wise rules", (Sydney Water 2016). Droughts have progressively become worse, and will be more severe in the future. (Nicholls 2004). Based on these trends, the kitchen and laundry areas appear well covered. Future improvements depend mostly on incremental efficiency through technology optimization (e.g. dishwashing, clothes washing and drying). However, the bathroom area shows opportunity to implement persuasive technology and water conservation solutions.

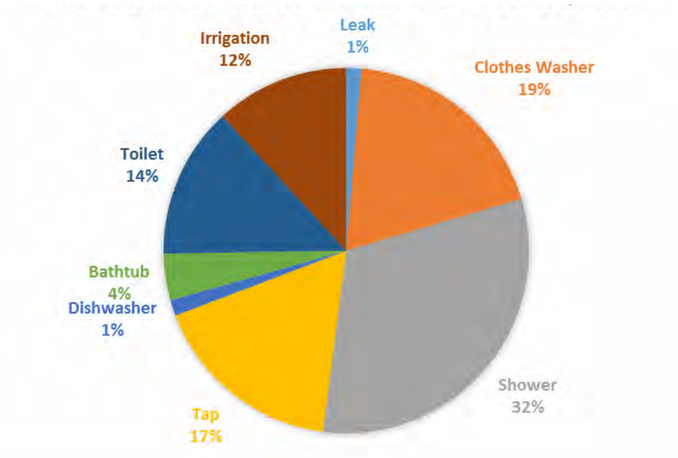

Figure 1 Household water usage in Gold Coast, QLD

A primary way children learn is through their parents and people around them (Caraban et al. 2014). Their learning between age 3 to 5 is strategically important, Mintz and Aagaard (2012) found behavioral and attitudinal formation develops at that age when still learning right from wrong and how to undertake basic everyday lifestyle tasks. Harris and Goodall (2008), showed there is a link between the involvement of parents and the success of children learning. Duckworth (1964) suggested while referencing Piaget, both children and adults benefit from this experience and both learn from "doing". Children are naturally inquisitive and learn best when interested in something and explore (Lucero et al. 2006). Therefore, they may also influence immediate behavioral change in adults and later future generational change on sustainability and society. Technology can well be a learning catalyst in their relationship (Caraban et al. 2015).

Persuasive technology can positively influence behavioral change by getting participants to act differently through user interaction. Technology advances, computers and other forms of know-how have now the ability to persuade people. (IJsselsteijn et al. 2006). Systems that utilize these technologies are often referred to as Behavioral Change Support Systems (BCSS) and serve as "information system designed to form, alter or reinforce attitudes, behaviors or an act of complying without using deception, coercion or inducements” Oinas-Kukkonen (2010). That information can be effective in provoking a voluntary change in behavior for the user (IJsselsteijn et al. 2006) since it requires “Just in Time” information and experience to a user at the right time and place (Intille 2004). On the side of children, they have become also more reliant on technology to assist with their learning and interaction with adults (Yelland 2011). Technology has the ability to dynamically interact and maintain their attention span for a longer duration of time. By keeping a child engaged, giving them a hunger to learn more and learn for themselves will result in a more successful product.

4. Methodology

Methodology for this project was set up according to current design research and innovation parameters and design process characterised by state of the art review, framing of design challenge as a wicked problem, iterative design process and implementation from low to high fidelity prototyping while carrying out consultation and with users through participatory action research.

4.1 State of the Art

Review findings on systems, products and the human environment within bathrooms and water conservation demonstrated there is big variety of offerings on both extremes. Many eco-feedback devices are mainly handled by adults in the household and aim to increase efficiency control. At opposite end, many children toys use water as entertainment either through flow, bubbles or noise. However, there is not significative persuasive BCSS offers that capitalise on parents-children relationship, and the opportunity to make effective and long lasting behavioural and consumption change through their interaction. A number of systems, products, and environment boards were prepared as part of the state of the art review (Fig. 2)

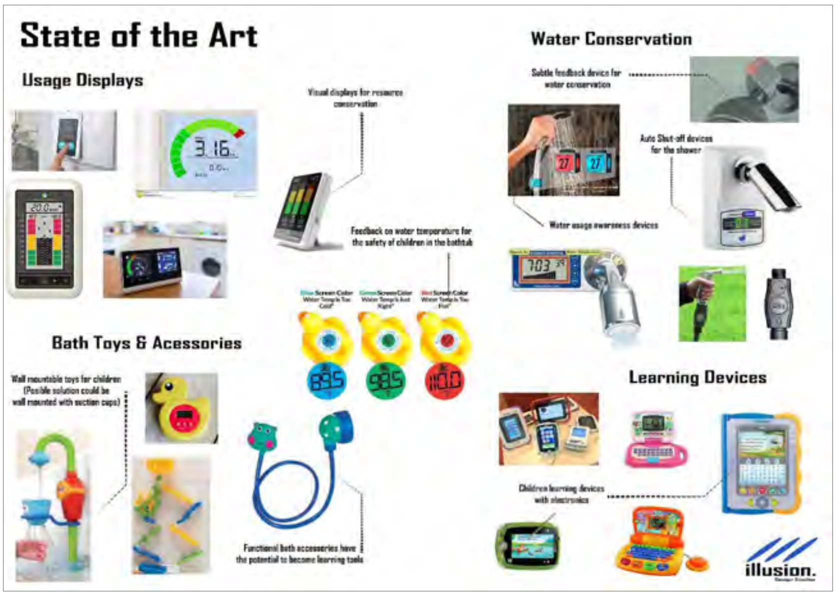

Figure 2 Sample of state of the art review boards.

4.2 Framing of Design Problem

Following on, a criteria framework was developed that intended to satisfy parameters of behavioural and cognitive development, design, interaction, learning, persuasive technologies and regulation (Table 1).

4.2.1 Design Process

Based on empathic, user research consultation and co-design participation, several concepts and low fidelity prototypes were developed to find out best design agency potential for the project. After assessment, a concept initially based on an off-the-shelf flow control mechanism grew to develop increasing effective persuasive influence. The mechanism was altered to allow collaborative measure user control, experience and interaction among parents and child. Persuasiveness would be achieved through improving interaction and participation with an interactive artefact assisted by human computer interaction based on Arduino programming and implementation (Fig 3). It pursued to make users capable to build meaningful relations through a touch screen, application of gaming theory (allowing for increasing complexity), and introduction of sustainability values through characters, graphics, storytelling and sound. The ultimate goal was for parent and child to be empowered through playing as a way to form, change and improve behaviour while making sustainability issues part of daily life experience (Fig 4).

Table 1 Research framework and pursued outcomes

Category	**Criteria**
Safety	Safe for children aged 3-5 Safe for use around water Any electronic components contained securely in waterproof housing No Mains (240V) power – Low voltage batteries only. Must have a barrier between ANY electronic components from the water
Use for children	Aged 3-5 Engaging for the children Facilitates learning for the child Stimulates the child's brain
Testing	Must be progressively tested throughout the design cycle User testing must be undertaken to validate and verify the design.
Persuasive technology	Positive and encouraging Familiar or easy to understand interface Must provoke a change in behavior, or promotion to a better habit
User engagement	Incorporate both the child and parents Promoting conversation between the parent and child to compliment the device May be supplied with a 'guide' about how to engage the child
Eco Feedback	Must utilize real time feedback about water usage Feedback must be in a relevant format for the audience
Installation	Minimal installation required Simple to use, and easy to install Universal design to maximize compatibility with external hardware and fixings

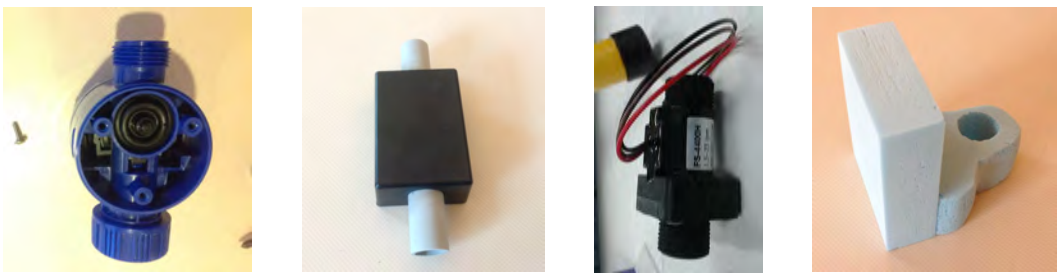

Figure 3 Sample of design process iterative prototypes.

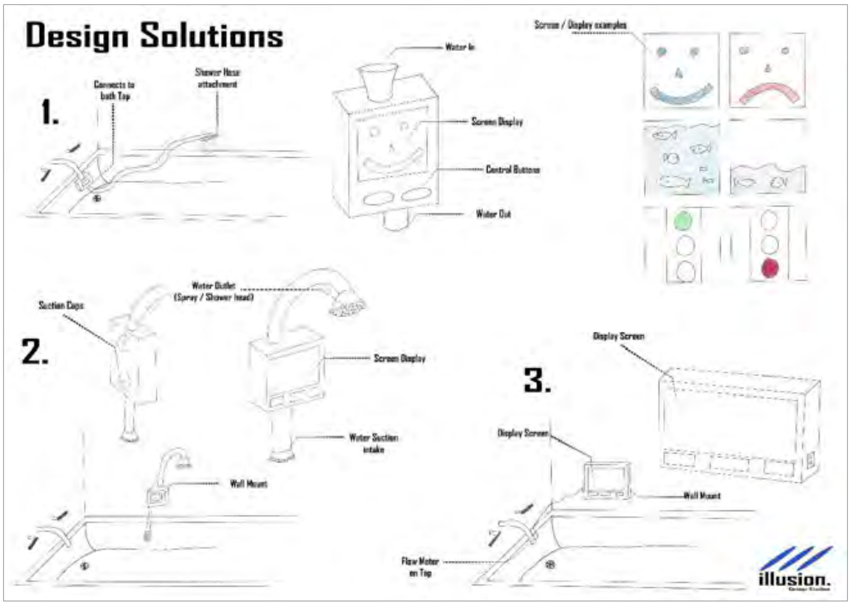

Figure 4 Sample of persuasive BCSS water flow system and basic touch screen sketches.

4.3 Focus Groups

A model (Fig 5) and several design interaction sketches were produced in preparation of two focus groups sessions. According to Australian ethics recommendation, sessions were conducted by consulting 10 parents who could liaise and represent their children at this stage.

Figure 5 CAD modelling and 3D prototyped model.

4.3.1 Focus Group 1

The first session focussed on gathering information from parents on children likes, dislikes and behaviour during the bath task. Queries on whether teaching children through practice and experience (project-based learning) was welcomed. Parents were very positive about the device giving many feedback and contributions. Among them

- There were clear potential benefits coming from the project in assisting on areas of mental (attention, problem solving, art, spelling, maths, etc.), physical (coordination, strength, interaction, etc,), affective, relationship, behavioural and cognitive developments.
- It would facilitate instilling good habits and values by discovery rather than forcing them in tasks participants during a daily ritual that currently is more of a routine functional shore
- The device seemed enjoyable enough to turn children into active participants in the routine through controlling or warning on water control, prompting and timing tasks (e.g. soap, shampoo, conditioner), reward or score system, competition with siblings on data gathered
- Several suggestions relating to water proofing, and children behaviour by touching, grabbing and pulling that should be considered in product development. Potentially, the screen could work assembled as one device or separated from the tap for more flexible user interaction

- The device would ideally sort out a way to assess water control by calibrating measure for safe water level
- Also, the device could be used in other instances (e.. kitchen, garden tap) once universal tap connection was sorted

4.3.2 Focus Group 2

Second session focussed on human computer interaction through the touchscreen. A four areas of interest criteria focused on entertainment, persuasiveness, understanding, links to everyday life (Fig 6). The exercise intended to assess 10 different themes, stories and games (Traffic lights, Stars, Emoji, Number of Fish, Sea creatures, Submarine, Ducks, Gauge, Man on a boat, Buckets of water). Participants considered, experienced and provided feedback that greatly supported the use of interactive storytelling, narrative and games with the use of images, animation, melodies and sounds to attract children interest and participation in the tasks. Among them

- Combined results showed participants preferred the sea creatures, number of fish and gauge themes. Nevertheless, the latter was said too complicated for younger children and limited in scope potential
- Stories and games that involved sequencing and organising were preferred as children like routine and repetition in their process to set values, learn principles and rehearse memory
- Learning through colour was seen with potential to extend beyond the bathtub scenario (e.g. red, yellow and green may show significance when cross the road later on)
- Principles of quantity, relationships affected by context was considered beneficial for children understanding through prompting of images, sound as part of interaction with parents (e.g. number of fish for amount of water in a tank, bucket of water)
- Support to develop animations, games and storytelling further in process of implementing successful interaction, human-centred design and persuasiveness

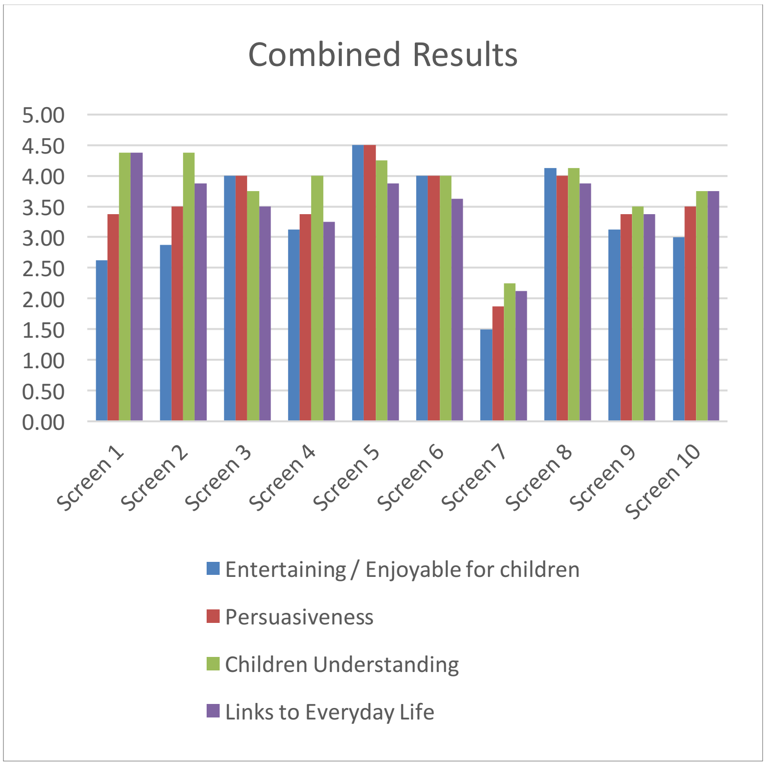

Figure 6 Statistics results from focus groups sessions.

4.4 Conclusion and Future Work

In this project to date, literature and state of art review have shown behavioral formation and change in favor of sustainability and well-being happens preferably through daily familiar practice rather than regulatory or financial penalty, as with water bills. There are not clear solutions that join sustainability, water management, eco-feedback and persuasive benefits (especially not as in bath task in the bathroom environment). Design research and human-centred design have demonstrated most devices aim for efficiency rather than effectiveness. Most devices belong to the former and work based on controlling measures and are generally punitive. The latter types open up to long lasting improvement based on a participatory culture on sustainability as they can potentially enable stronger family ties, lifelong learning and habit change through design intervention (co-design, HCI, industrial design, participatory action and persuasive design). Users participatory sessions opened up a clear path for that intervention. With this, the project currently is underway to new product development on user device interaction, relationship building and belonging through narrative, storytelling and game design. Importantly, the BCSS proposed is now considered a device as platform within a persuasive system rather than an isolated functional product design. Parents and children are seen now with the potential to access, own and reconfigure the system through play and experience, software and semiotic application, exchange as means of forming and changing behaviour and assist cognitive development. All in the process of its next iteration stage to produce a minimum viable product (MVP) and systemic solution closer to production.

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Innovation as a Transversal Competence In Engineering And Technology Training The Transformation of Grey Literature as a Tool for Innovation In Engineer Training

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Abstract: The aim of this work is to present a study which charactezes the importance of storage of the content generated from searches of TCC's of graduate programs in engineering like Grey Literature (LC) of the higher education institutions (IES) in Brazil and submit the Institutional Repository (RI) as innovation strategy to contribute to the development of transversal competence of the engineer. The study presents a aggregator mechanism to higher education emerging as lever of "innovation using the transversal competence in engineering and technology "noting-if the stimulation to the cultural creation and the development of scientific spirit and reflective thinking, encouraging the research and investigation. The main objective is to make a fuss about the need for a study to characterize the research that generate the work of completion of courses (TCC's) in Engineering higher education institutions (IES) in Brazil and submit the Institutional Repository (RI), as a strategy for innovation in order to contribute to the development of transversal competence of the engineer. The disciplines of project and conclusion of course of graduation in engineering contributes so relevant to the professional future, once the same, while student, on the identification of a problem, learn how to get information from research, readings, reflections, discussions, among others, to respond to their needs, reducing uncertainty and promoting a new knowledge which will also be registered through the work of conclusion of course (TCC).

Keywords: Institutional Repository; Grey Literature; Innovation; Engineering; Learning;

1.Introduction

Among the purposes of higher education in most engineering courses, this work focused on investigation of the format of TCC's (work of completion course) and stressed the following purposes: a). Stimulate the creation and cultural development of the scientific spirit and reflective thinking; b). To encourage research and scientific research aimed at the development of science and technology and the creation and dissemination of culture, and thereby develop the understanding of man and the environment in which he lives; c). Promote the dissemination of the cultural, scientific and technical knowledge that constitute heritage of humanity and to communicate knowledge through teaching, publications or other forms of communication (Souza; Silva, 1997)

Second Coast (2006) the system of scientific communication has significantly suffered the impact of electronic media, most recently with regard to open access to scientific literature. In this sense, electronic scientific journals to open access and institutional repositories increases the dissemination of the research of exponential mode, maximizing its impact, its visibility and its advance.

To start the production process of an article, the specialist produces sketches of his ideas for comments among their peers. This procedure, originally made only between researchers, was enlarged and developed with the emergence of the archives and open access repositories. These technologies offer a more functional organizational structure of literature than the current existing organization in the process of revision among peers.

The Final Projects and the work of completion of courses (TCC's) higher education institutions should be considered as real "diamonds" with informational content that can be lost, due to lack of proper management of this source of information. Petinar (2007), mentions that the open-access repositories, would allow all Community (academic or otherwise) to have access to the first research initiatives (monograph of graduation), elaborated and developed by graduate students, collaborating with the dissemination of scientific knowledge.

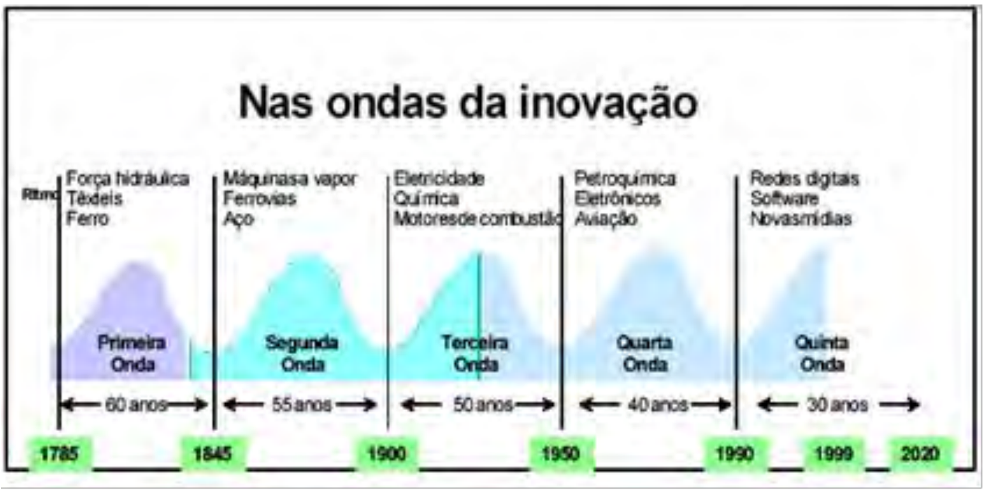
The specific problem of LC resulting of works and researchs, that are generated by the work of completion course and the Final Projects of graduate in engineering, in addition to the graduations, in General, are normally delivered only printed and in digital form, catalogued and entered in the system by the Librarian, in general are not made available in electronic media only appearing cataloged information of the work, which ends up causing delay in search of that content. For a user (researcher, teacher and student) have access to Final Projects, is impractical. Another question is how the visibility of the scientific production of the graduate, and consequently on the part of researchers and teachers. This inoperative process transforms innovation in Grey Literature (LC).

The Institutional Repository (IR) must contribute to the community to have access to the first research initiatives (TCC's and Final graduation Project), developed by undergraduate students. (Pertinari, 2007).

The aim of this work is to present the discussion of how the RI must contribute to the development of innovation in undergraduate program in engineering, based on the search engines that do not allow that despise the contents of research of technological innovation that are formed by TCC's and Final Projects of undergraduate courses in engineering.

The search for novation is an investigation imbued with difficulties to achieve. Let her get lost is not consider its importance. The ranges of the waves that classify innovation from the point of view of research, are approximately ten years. The waves of innovation of Bussinger, starting in 1785, with the emergence and predominance of the use of hydraulic forces, textiles and iron. Then, until the beginning of the 20th century, appears the second wave, with the predominance of steam engines, the railroads and the extensive use of steel.

Figure 1- Technological innovation through the ages



Fonte: The Economist; Bussinger (2000).

These changes have required that companies seek contemporary, increasingly, innovation, to offer new services in new environments. Demands, too. Deepening the relationship with their customers, through knowledge of their customers, their needs and desires, in order to achieve superior quality measures and produce more added value to the process.

2. The repository (IR) as an instrument of Innovation

Scientific and technical activities are responsible for the production of knowledge that will become, after registered, on scientific and technical information. Second, Le Coadic (2013), conversely, these activities only, only come true by this information. The information is the lever of science. Without information, science does not develop. No information would be useless research and knowledge lost.

Considering that this lever must move freely to produce knowledge, if there is a treatment of the sources of information produced by the University, you lose the knowledge. In this context, the Mission of the University is the socialization of knowledge, the democratization of education. Available through the RI University scientific production is socializing the knowledge and democratize scientific information of quality in relation to society. Access to information creates possibilities for changes within society. "Therefore, the access to information and knowledge is regarded as a fundamental component to the exercise of citizenship in a democratic context" (Vitorino; Piantola, 2011).

The fact that this knowledge is not available to society, defined as Grey Literature:

> “(...) the term Gray Literature is used to designate non-conventional documents and almost published, produced in the areas of Government, academics, business and industry. (Gomes; Marin; Sharma, 2000)”

Machado (2005) mentions the peculiarities of Grey Literature are: do not have records on the intelligence agencies, not through commercial sources, have simple production mechanisms, are in universities, research centers and reach a small audience. Campello (2000), reinforces that although universities and colleges, research fostering agencies, ministries of education and of science and technology is committed to disseminating these publications, its visibility is still very restricted.

3. The construction of Institutional Repositories As Effective Instrument for innovation in engineer Training

The discipline of projects and completion of course in engineering meets contribute so relevant to the professional future, once the same, while student, on the identification of a problem, learn how to get information from research, readings, reflections, discussions, among others, to respond to their needs, reducing uncertainty and promoting a new knowledge which will also be registered through the work of conclusion of course (TCC).

This work also demonstrated that as guidelines of higher education have contributed to the future student in professional terms, because there is no process of teaching and learning, the commitment to develop on individual an investigative and reflective side doing the same, in front of a particular problem or challenge in his professional life, evaluate possible solutions based on scientific units, reproducing consciously or unconsciously, the steps taken at graduation when it developed its TCC.

The visibility of scientific and technological knowledge through the RI, demonstrates that the globalized world produces, at a pace never seen before, a huge range of scientific and technological knowledge. As a result, there arises the concern with its dissemination, availability and preservation. To Rocha (2006), the change in search processes and use of information generated faster and more efficient forms of information retrieval. The media as paper and magnetic metallic surface disintegrate or may become unrecoverable, and the digital objects minimizes the action of time on the physical media. With this, ensure the availability of information, however, these must not be left in obsolete formats for long periods, requiring updating.

4. The construction of the Institutional Repository (IR)

The construction of an institutional repository involves steps of planning, deployment and operation. These three phases are interdependent and consist of activities that must be met in order that the construction initiative of the institutional repository is successful. Of course, this is not the only way to build institutional repositories, but the proposed scheme covers relevant aspects that should be considered in this kind of venture. This document will stop the discussion of some aspects of the proposed phases for Leite (2009), seeking to present a set of best practices for the creation and management of institutional repositories.

a) Planning

In step is very important to develop and implement an institutional policy for the operation of the institutional repository. The operating policy should reflect decisions taken throughout the store planning. It is recommended that this policy is in line with those already in effect in the library and in the institution.

b) Definition of Institutional Repository policies

The policy should address the objectives of the repository, must contribute to the definition of the service, determine the formation of the team responsible for the implementation and maintenance of the repository and on the deadline set for the deposit in the repository. It must also contain the kind of material that will be deposited, as well as those who are not part of this system. The repository operation policy also should establish, who should make the deposit, the responsibilities in the workflow, and all other aspects that institutions consider that should come to contribute/ensure their operation of the repositories.

c) Structure of the institutional repository

Is in the planning phase should be designed the information architecture of the repository. It is understood as information architecture, in this case, the Organization of content. Each institutional repository organizes content in a way that best fits your needs by adjusting the structure of the RI to the operation as a whole.

4.1 Institutional Repository deployment

The deployment step must be observed the following aspects: the metadata that have the purpose of register of journal articles; papers presented at academic events; Book chapters; Book and according to purpose of this study, registering also the contents of TCC's of engineering and also establish rules for standardizing the most used document formatting.

The ideal scenario is that intellectual production of the institution were stored and could be freely distributed on the Internet. However, the copyright of the content assets, especially most articles published in scientific journals, are the property of scientific editors. It is interesting to understand the aspects of copyright in order to avoid problems.

5. Final considerations

The research points to to promote evaluation with statistical basis proposed institutional repository model, because, as any information system, you will need to go through some benchmark for comparison, in order to improve fragile aspects and identify their points of success and opportunities for improvement, considering mainly the aspects that will be used as indicators of quality.

The open access repositories allow the whole community (academic or otherwise) has access to the first research initiatives (TCC of graduate), elaborated and developed by students, collaborating with the dissemination of scientific knowledge. The Institutional Repository (IR) is a strategic instrument, contributing to that the community has access to the research developed by graduate students, through its Work of conclusion of course (TCC's), transforming contents considered as Grey Literature (LC) in scientific research as knowledge production.

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Women's Aspirations towards Engineering Education in Sri Lanka

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Abstract: This paper presents results of a nationwide survey conducted in Sri Lanka selecting a stratified sample of 2351 students in the final stages of their secondary school. The sample comprised 841 female and 1510 male students. The focus of the survey is to find out what options the students are envisaging to embark on in case they fail to secure a placement out of the limited seats available at state universities. The responses displayed that there is a bias in the options selected by male and female students. Larger percentage of male students (72.7%) compared to 67.6% of female students are prepared to give up the idea of engineering studies mainly due to financial difficulties. This trend is explained by the social obligation the male students have to support the family through immediate employment whereas such pressure comes on female students only if they have no male siblings. While only 9.2% of the male students consider undertaking studies overseas a slightly larger 10.5% of the female students consider that as an option. This also indicates that the financial support from the family is equally likely for the female students as the case is for the males.

Keywords: Engineering education, Gender, Financial support, Survey

1. Introduction

Sri Lanka, the country that produced the first ever female prime minister in the world, has made headways in opening the door of higher education to women. Women in Sri Lanka have been successful in achieving high levels of participation in professions like office staff, teaching and medical services including the medical practitioner domain. However, women's participation in Engineering and technology related professions have been traditionally low as elsewhere in the world, both developed and developing. Gender distribution in undergraduate enrolment in Sri Lankan state universities has gradually improved in many disciplines as shown in figure 1 published by University Grants Commission, Sri Lanka (2016). Women enrolments in all the academic programmes other than Engineering, Architecture, and Science and to some extent Law are very good. Further, Engineering and Architecture shows the lowest level of women participation.

Apart from providing equal opportunities for women in the lucrative engineering profession, diversification of the engineering work force brings additional benefits. Diversity in learning style, worldview, problem-solving orientation, attitude and approach towards subordinates and superiors among many others through race, ethnicity and gender bring new dimensions into the work environment and productivity as posited by Felder & Brent (2005). In a 1991 survey discussed by Felder et. al. (1995), roughly 20% of the respondents cited beliefs that engineering is too demanding to combine with family responsibilities and most parents discourage their daughters from training for engineering. However, in the present day Sri Lanka this argument does not hold true as females readily engage in other professions like medicine which are equally, if not more, demanding and interfering with family responsibilities.

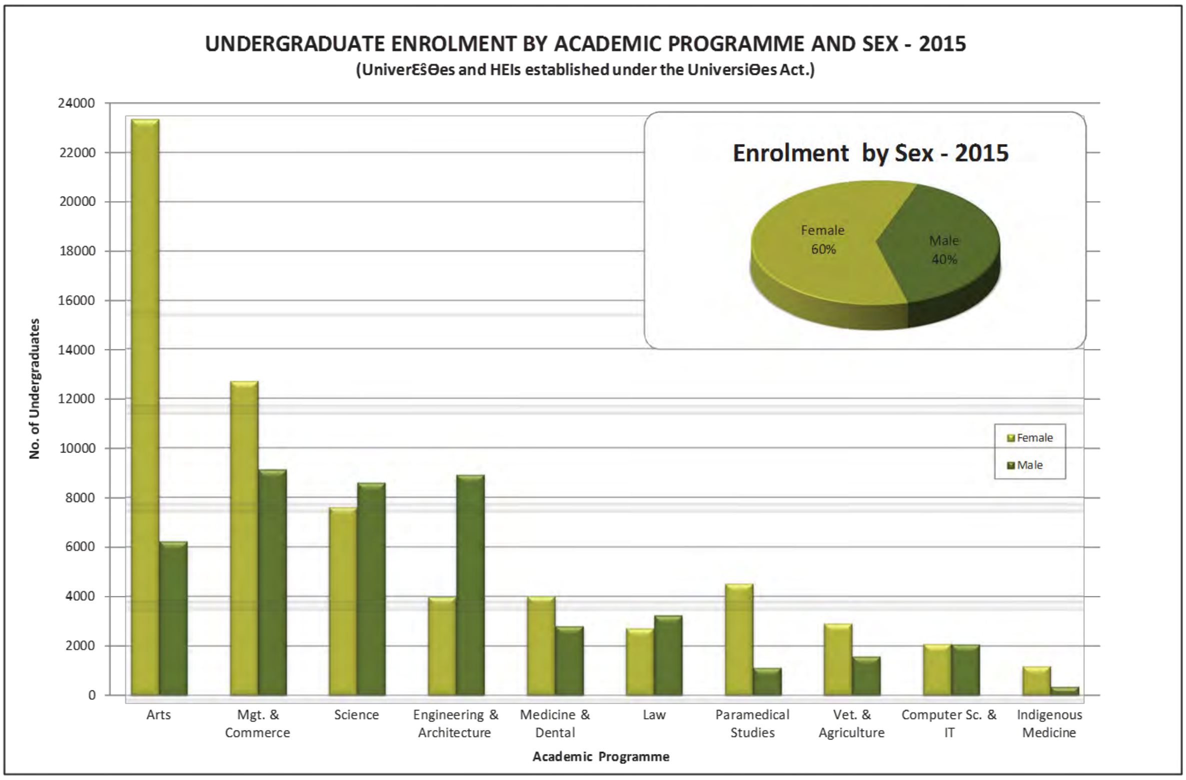

Figure 1Gender disparity in undergraduate enrolment

2. The survey

A nationwide survey was conducted to gather information from secondary school students who are either following the General Certificate of Education, Advanced Level (GCE A/L) or have just completed the examination in the Mathematics stream. Students in Sri Lanka complete the General Certificate of Education, Ordinary Level (GCE O/L) after 11 years of schooling and then gain admission to study for GCE A/L which is of two year duration. GCE A/L is simultaneously the University Entrance examination for the admission into state Universities and majority of private Higher Educational Institutes in the country. Students select three subjects out of a basket for GCE A/L and depending on the subject combination five streams are defined. The streams are Science, Mathematics, Technology, Commerce and Arts. The students selecting Mathematics stream study the three subjects, Combined Mathematics, Physics and Chemistry. Whatever the stream selected students also have to follow General Information Technology and English as a second language and sit and pass a general knowledge test at the end of the two years of studies. Only the students passing all three subjects in the Mathematic stream become eligible to apply for a placement in a state Engineering Faculty. Due to the heavy competition only 17% of those eligible manage to secure a placement in a state Engineering Faculty.

The survey, based on a two well-structured questionnaires, was carried out over 25 districts in Sri Lanka. The first questionnaire was for the students while the second was for their parents. The survey was targeted in ascertaining the information pertaining to the preferences of students in pursuing Engineering degree study programmes and their affordability supported by the parents.

In arriving at the total sample size (n), the following formula was used:

$$n = \frac{N}{1 + N \times e^2} \qquad (1)$$

where, N is the population size which is estimated to be 30,000 and e is the error margin. To achieve 95% confidence interval an error margin e = ±1.98% is taken. Thus

$$n = \frac{30000}{1 + 30000 \times 0.0198^2} = 2351 \qquad (2)$$

A sample comprising 841 female students and 1510 male students totalling 2351 was selected. The fact that there are significantly more male students following the specified subject combination led to select more male students than females (convenience sampling). For the second part of the survey gathering information from the parents only 1015 of the questionnaire was received back mainly due to limited access the enumerators had to the parents. Undergraduate students from University of Moratuwa engaged as the enumerators.

Multi-stage sampling method was used where the first stage is stratified sampling based on geographical areas (25 educational districts) and the second stage was convenience sampling within each stratum (district).

3. Results

3.1 Information gap

Only 63.2% of the students gave a meaningful response to the question "What field of Engineering would you like to undertake studies in?" This implies that more than one third of the students are not well informed about the different fields of engineering and/or have not seriously thought about their future plans. This gap existed nationwide and no consistent variation was observed between high per capita income districts and low income districts.

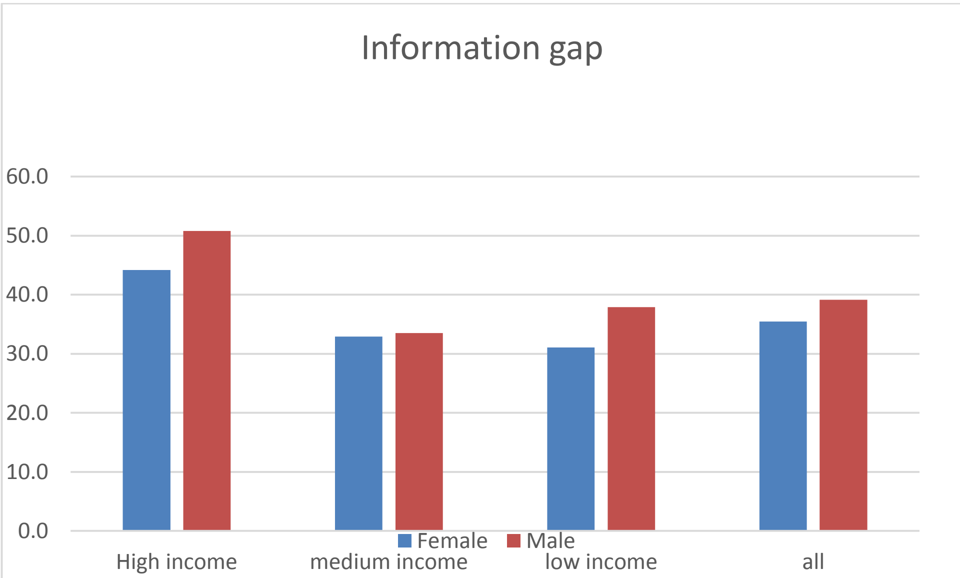

Figure 2 Information gap for male and female students over different districts

However, more female students refrained from answering this question than male students. This trend is observed in all the districts and differences do not show any significant correlation with the income level of the districts, see figure 2. Thus the female students are lesser informed about the different fields of Engineering than their male counterparts.

The reasons for this could be manyfold. Firstly, the female students are apparently not exposed to all the information that are available to the male students. Secondly, the female students do not engage in discussions with their peers, friends, teachers and relatives on technology related topics to the same extent the male students get involved in. Moreover, the female students are less concerned on planning their future compared to the male counterparts. As shown in figure 2 the gap is still significant though not alarmingly wide. As seen in the figure 2 both female and male students in high income districts are better informed compared to their counterparts in medium and low income districts but the differences between medium and low income districts do not show the same trend. In the medium income districts only 32.9 % of the females and 33.5% of the males responded meaningfully, while in low income districts the response rate was slightly higher from both groups.

3.2 Bias towards softer fields of Engineering

As discussed by Stonyer (2002) engineering is viewed in the public sphere as masculine, competitive and impersonal, qualities that women find difficult to arrange themselves with. Reflecting this behaviour female students responded in the survey, display a completely different pattern in selecting their field of specialization compared to selection pattern of the male students. In filling the questionnaire the students had the freedom of giving their preference in writing. Students have indicated a wide spectrum of fields and in order to limit the number of fields certain fields were counted together taking international practices into account. Fields like construction, coastal, mining or environmental engineering were all counted under civil engineering while fields like automobile, marine, textile and aeronautical were counted under mechanical engineering. All the computer related fields like computer engineering, software engineering and information technology were counted together. As the preferences indicated by females and males in Electrical engineering and electronic engineering showed some difference they were counted separately. However, electronic engineering and telecommunication engineering were counted together. The field of chemical engineering was also counted separately. In case a student gave two fields only the first indication was counted.

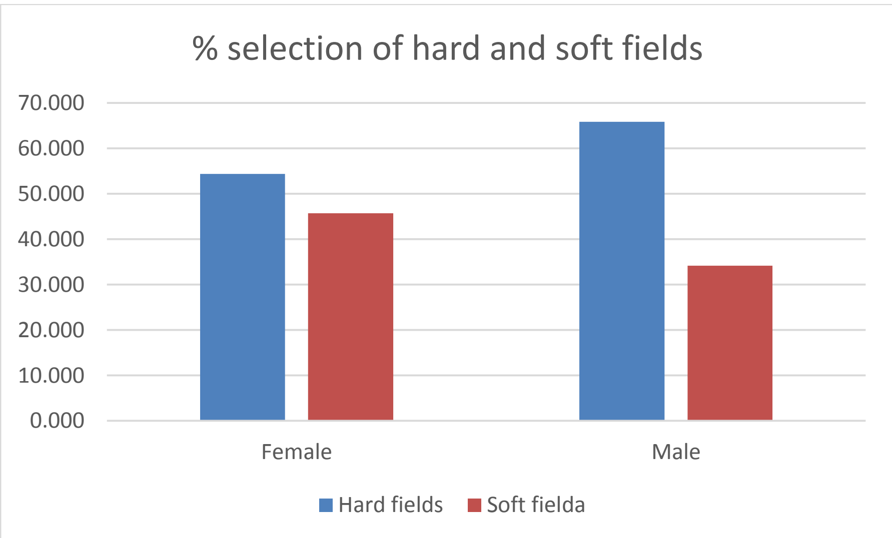

Figure 3 Selection of hard and soft fields

First the fields were grouped into hard and soft fields. Civil, chemical, electrical and mechanical fields were grouped together to make hard engineering while computer engineering and electronic and telecommunication engineering were put together into soft engineering. Both female and male students predominantly selected harder fields of engineering. However, 68.8% of male students have selected harder fields of engineering while only 53.4% of the females have gone for that option as shown in figure 3. This indicates that female students still prefer office work rather than going for field work, site work or factory work.

As shown in figure 4 even out of the soft fields the computer related work is heavily preferred by the female students. When it comes to hard fields of engineering female students find civil engineering and chemical engineering highly attractive. Additionally, the fact that civil engineering involves a lot of design work is desirable for women engineers.

Analysis of GCE A/L results show that female students perform very well in the subject chemistry, while male students do better in Mathematics and Physics. In addition to the strength of the female students in chemistry, the fact that chemical engineering encompasses areas like food processing and pharmaceutical production makes chemical engineering more attractive for females. This makes 7.0% of the female students to opt for chemical engineering compared to mere 1.6% of male students going for the same field. The opposite is visible related to the field of mechanical engineering. Only 11.0% of the female students wish to follow mechanical engineering while 27.1% of the males target the same field. This agrees with the opinion expressed by Stonyer (2002) that women prefer engineering to be linked to social context and needs and to work in cooperative environments that encourage engagement with peers.

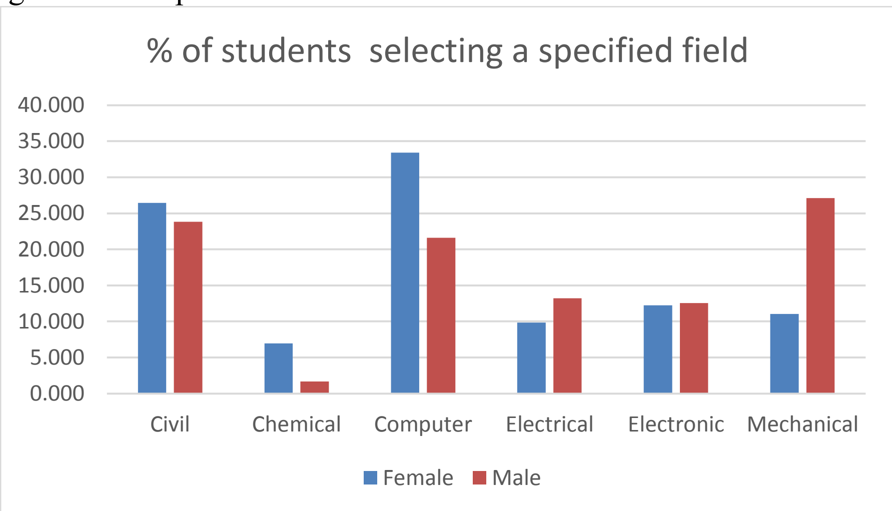

Figure 4 Field preferences of male and female students

3.3 Tendency to give up studies

Though the students have intension of studying engineering, there are uncertainties whether they could secure a placement in a tuition-free state University. Failing to secure such a placement, students have the option of enrolling in a fee-levying private educational institute. However, not everyone can afford to pay the tuition fees and such students tend to go for other options. Alternative options selected by female and male students show a wide variations. While 72.7% of the male students questioned are prepared to give up the idea of engineering studies, only 67.6% of the females think of going for other options. Some students tend to go for less competitive study programmes in the state universities while others (9.5% of the total sample) decide to quit further studies and seek employment. Larger percentage of male students (11.7% of the males) opt for this compared to significantly less 5.6% of the female students. This trend is explained by the social obligation the male students have to support the family through immediate employment whereas such pressure comes on female students only if they have no male siblings.

3.4 Undertaking studies overseas

Undertaking engineering studies overseas is a popular option among students from financially strong families. Out of the total sample 9.6% of the students declared this as an option. While only 9.2% of the male students considered this as an option, a slightly higher percentage of female students (10.5%) expressed that they plan to undertake overseas studies in case they do not find a suitable placement within Sri Lanka. This indicates that at least in financially strong families both males and females have equal access to funds for education, which is a very positive trend compared to the situation several decades back. 15.2% of the parents questioned indicated that they are prepared to financially support their children to study for an overseas engineering degree. However, data was not available on the number of children they think of supporting and their gender.

4. Conclusion

Gender distribution in undergraduate enrolment in Sri Lankan state universities has gradually improved in many disciplines. However, Engineering and Architecture shows the lowest level of women participation. It is evident that over one third of the prospective students are not well informed about the different fields of engineering one can study. This information gap is wider when it comes to female students.

Female students targeting to undertake engineering studies still prefer softer fields of engineering like Computer and Software Engineering and Electronic and Telecommunication Engineering. Out of the harder fields of engineering female students prefer fields like Civil and Chemical over Electrical and Mechanical Engineering.

In the event of failure to secure an affordable placement, more male students tend to quit further studies compared to female students. There is no gender discrimination when it comes to personal funding of engineering studies in a foreign university.

Acknowledgements

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Combining Experiential and Problem Based Learning: An Application in Fluid Power

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Abstract: During active learning exercises, students are engaged in their own learning. As a result understanding and retention generally increase. This paper describes a class in which several forms of active learning were combined to design a module where students applied the mechanical energy balance to both Newtonian and non-Newtonian fluids, and created a pump characteristic curve. The students were given an exam shortly after they presented their solution. There was no statistically significant difference in their scores compared with students who had been taught the material in a traditional classroom by the same instructor.

Keywords: Engineering education, problem based learning, experiential learning, fluid dynamics,

1. Introduction

Socrates asked his students leading questions, forcing them to be intellectually active – this exemplifies active learning. According to Prince (2004), any method of teaching that engages students in the learning process constitutes active learning, and develops students who become responsible for their own learning. Active learning

- Increases the percentage of students who understand concepts (Prince 2004).
- Improves long-term retention of the material (Felder 2000).
- Has been linked to more enjoyment of the course and higher graduation rates (Rich 2015).
- Leads to increased confidence (Kirkham and Seymour 2005).

One hundred years ago, Dewey (1916) described experiential learning, one type of active learning, as a process where a student participates in an activity, then reflects on what took place. He stressed that the reflection process is key to retaining the concepts from the activity. The literature shows a consensus that experiential learning is effective (Smith et al. 2005, Smith 2011). The instructors, however, must be active listeners and coaches in order to maximize student learning (Lalley 2007).

Problem based learning (PBL), another type of active learning, provides students with a real problem to solve. A relevant problem is introduced at the beginning of an instruction cycle and is used to provide context and motivation for the students to learn (Prince 2004). The problem is open-ended and ambiguous. PBL has been shown to

- Increase students' problem-solving and critical thinking skills (Krajcik and Blumenfeld (2006), Savery (2006), Reynolds and Hancock (2010))
- Increase students' conceptual understanding (Yadav 2011) and knowledge retention (Prince 2004).
- Develop more positive attitudes and a deeper approach to learning (Prince 2004)

A small negative effect of PBL occurs if students have not had much experience with problem solving. (Prince 2004)

This paper will describe a module from an applied fluid power course, with four active learning exercises embedded within a PBL scenario. An overview of the module is shown in Figure 1. The students began the three-week module with a ranking exercise. During the next class period, one member of each PBL "home" group learned a subset of the material in a "subject" group, and then returned and taught the material to the "home" group during a jigsaw activity. Outside of class, each group performed a laboratory experiment. The module concluded with a gallery walk, where each group showcased a poster describing their final solution.

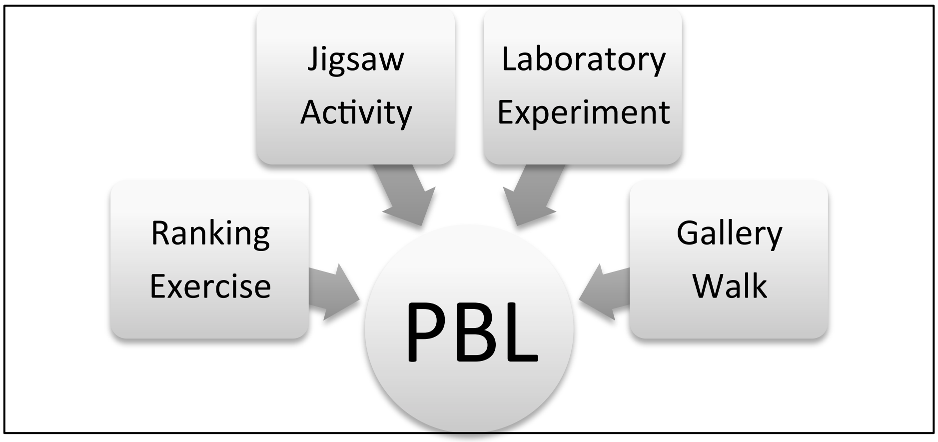

Figure 1 Module Design

2. The Course

"Applied Fluid Flow and Heat Transfer in Food Engineering" is a third year course taught to chemical engineering students who choose a non-traditional fluid power course option. The same instructor taught a traditional fluid power course to the remaining third year students. All students had completed a theoretical fluid dynamics course the previous semester. Both courses meet twice a week for a 1-hour period and once a week for a 2-hour problem-solving period and have the same student learning objectives.

As in most fluid power courses, the mechanical energy balance is a central theme. One of the main applications is pump choice and sizing. Many courses have an accompanying laboratory where students run water through a pump loop and measure pump power, head and efficiency. However many fluids – and most foods – are non-Newtonian, and pumping these fluids can be significantly different from pumping water. The PBL scenario was designed to illustrate the differences and help students learn how to design systems for non-Newtonian fluids and to determine when to use the various types of pumps.

3. The Project

An effective project for PBL should be realistic and scenarios familiar to the students are especially effective. In this project the students determined if a recently abandoned local soda-bottling factory could be used to bottle ketchup. The problem statement is shown in Figure 2 and the learning objectives are summarized in Table 1.


ChE 320 Project 1

Lehigh Valley natives love A-Treat soda. It has been a valley favorite since 1918, and when the plant abruptly closed in January 2015, the soda, especially the orange cream flavor, became a big seller on eBay. The soda proved to be so popular that in August 2015, The Jaindl Companies purchased the A-Treat brand, and The Coca-Cola Company began to bottle the soda. Ten flavors are now available (Orange Cream, Black Cherry, Birch Beer, Cream, Big Blue, Ginger Ale, Sarsaparilla, Orange, Root Beer, Grapefruit and Diet Cream), much to the delight of locals.

But – the old bottling facility in Allentown is sitting empty and unused. What can be done? Last summer, I had a bumper crop of tomatoes, and developed a prize-winning ketchup recipe. Can I use a facility that used to bottle soda, and use it to bottle ketchup?

A quick look inside the plant provided this information:
Storage tank dimensions: 0.2m in diameter by 0.7m high
Elevation from pump to top of line: 1m
Elevation from top of line to bottle filling opening: -0.3m
Pipes: ½ inch Sch 40
Total pipe length: 4m

Figure 2 PBL Problem Statement

Table 1 PBL Learning Objectives

Learning Objectives: At the end of the project, the students will be able to • Understand how a non-Newtonian fluid's viscosity is characterized • Describe how a pseudoplastic fluid behaves when sheared • Understand why different pump types are used for non-Newtonian fluids • Create a pump characteristic curve • Explain the difference in the curves for Newtonian and non-Newtonian fluids • Compare friction losses for the two types of fluids • Apply the mechanical energy balance to various pumping situations for both Newtonian and non-Newtonian fluids.

The students participated in a ranking exercise on first day of the module. Student groups were provided with toothpicks, popsicle sticks, and small containers of ten fluids, such as mayonnaise, olive oil, corn syrup and ketchup. They poked, stirred and poured them, and then ranked them in order of increasing viscosity. Each group put their list on the blackboard to compare rankings. A discussion on non-Newtonian viscosity followed.

The PBL scenario was introduced during the next class period. The students were provided with the problem statement and specific guidelines for a final report. After reading the statement the groups spent about ten minutes brainstorming questions they had about the process and the project, and what information they would need to complete it. No formal lectures were given in class, but links to relevant information were provided and the instructor circulated around the classroom, answering some questions and guiding students to the relevant information as they asked.

That same day students next participated in a jigsaw activity, where one person from each "home" group joined to form an "expert" group on a topic. The expert groups completed worksheets on three topics: Applications of the Bernoulli equation, Calculation of friction losses and pump sizing, and Classification and calculations for power law fluids. After 45 minutes in the expert groups, the students returned to their home groups and taught what they had learned to the other members.

The experiment was done in the midst of the PBL, outside of class. Four concentrations of xanthan gum in water (a power law fluid substituting for ketchup) were provided. First, the students used a Brookfield viscometer to characterize the solutions' viscosity. Next, the students created head versus capacity curves for desktop fountain pumps (centrifugal) and capacity versus voltage supplied curves for a small diaphragm pump. Collecting the data for pumping the four fluids in the two pumps took about three hours. Supplies and equipment was purchased online for about $100. The students were given a list of relevant readings comparing the two pump types and information on pumping viscous liquids.

On the day the project was due the students participated in a Gallery Walk. During the first 30 minutes of class, the students prepared posters (70 x 90 cm) describing the main elements of their solution: could the soda bottling factory be used to pump ketchup? Each group explained their project during the final 20 minutes of class.

4. Results from the experimental portion

A typical plot of apparent viscosity as a function of shear rate is shown in Figure 3. Equation (1) shows the relationship for a Power Law fluid, where η represents the apparent viscosity [Pa s], γ is the shear rate [s^{-1}], K is the flow consistency index [Pa s^n] and n is the flow behaviour index. The groups obtained similar results, and because the flow behaviour index was less than 1.0, the xanthan gum solutions were characterized as shear thinning.

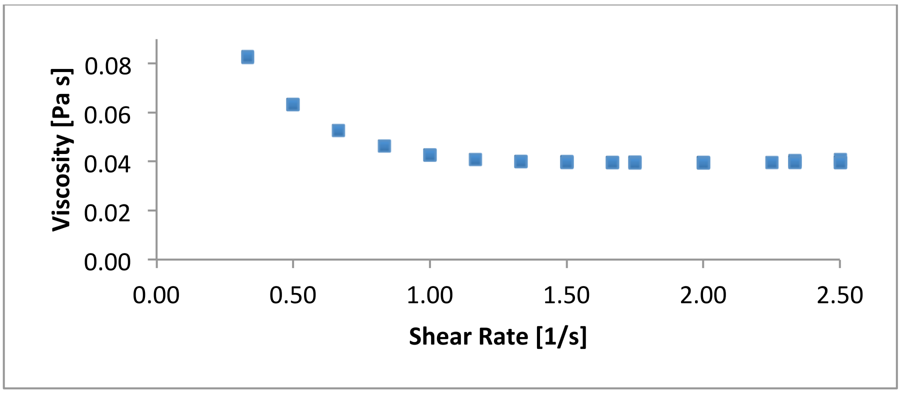

Figure 3 Typical viscosity graph

$$\eta(\dot{\gamma}) = K\,(\dot{\gamma})^{n-1} \quad (1)$$

The students created pump curves for the centrifugal pump by measuring the flow rate at various heads for the viscous liquids, as well as for water. A typical plot is shown on the right in Figure 4. Finally, the students measured the pumping capacity of a diaphragm pump for the different liquids as shown in Figure 4 on the left.

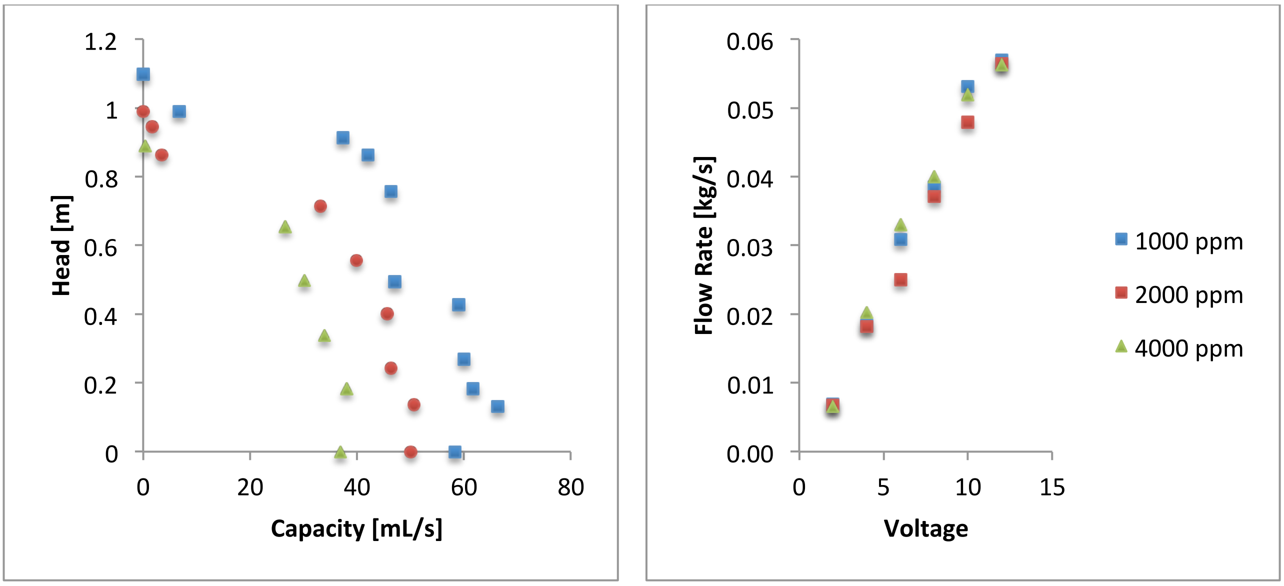

Figure 4 Pump curves for the centrifugal pump (left) and diaphragm pump (right)

5. Student learning

Using multiple types of delivery modes in the classroom generally leads to more learning (Moor and Piergiovanni 2010). In this module students learned from five different types of presentation activities. After each exercise, the students were given time to reflect and note what they had observed and learned. These reflections were an important part of the final report.

The students had used the Brookfield viscometer to characterize the viscosity of motor oil the previous semester. They determined it was a non-Newtonian fluid, but most had not thought deeply about what that meant. During the ranking exercise, as they poked and stirred various fluids, they recognized that some fluids became easier to move the faster they were stirred. Ranking the fluids was not an easy task – and there was no unique solution – but they were able to categorize the fluids into groups. This led to a discussion of apparent viscosity, and shear rates present in pipes and pumps, which are important when pumping non-Newtonian fluids.

During the jigsaw activity the next day the students were fully engaged in learning the material assigned to them. Their strong theoretical background made it possible – they were not beginning learners (Prince 2004). Using their textbook and the handouts provided, they figured out how to set up and solve applications of the Bernoulli equation and calculate friction losses in a typical system. The third group learned how to characterize a power law fluid, and how to adjust the Reynolds number and friction factor equations for these fluids. As the students returned to their home group the professor circulated and eavesdropped as the each student taught the other students what he or she had learned, and carefully corrected the few misconceptions. The method of instruction appeared effective as the students completed a final problem encompassing all concepts before they left the classroom.

While the experiments were completed outside of class time, the students continued to interact with the instructor when they had questions. They were able to linearize the power law equation and determine the characteristic parameters of the xanthan gum solution. Unfortunately, no group looked for literature values to compare with the experimental values for xanthan gum or a comparison to ketchup, and no assessment of error was made. They did recognize that the fluid was shear thinning.

The students clearly recognized that the centrifugal pump had more trouble pumping the viscous solutions, and could explain why. However, when they observed the plot for the diaphragm pump, initially they contacted the instructor complaining that the pump wasn't working, or that the method for collecting data was not precise enough. They expected that the PD pump would also show effects of viscosity. Instead of answering their questions, the instructor reminded them of the literature that had been provided.

Creating a poster requires students to prioritize their results. Two sample posters from the gallery walk are shown in Figure 5. The poster on the left compares the two pumps, and the poster on the right explains the conclusions from the PBL project. During a quiet gallery walk, students read the posters and wrote down questions they had while comparing others' work with their own. Each group then presented a 3-minute pitch for their poster. Both posters include some misconceptions or errors that were discussed in class. The work and power calculations for the poster on the right were done correctly – they are lower than expected due to the scale in the problem statement provided to the students, and will be corrected for future offerings. Overall, through the gallery walk, it was clear that the groups had met the learning objectives stated in Table 1.

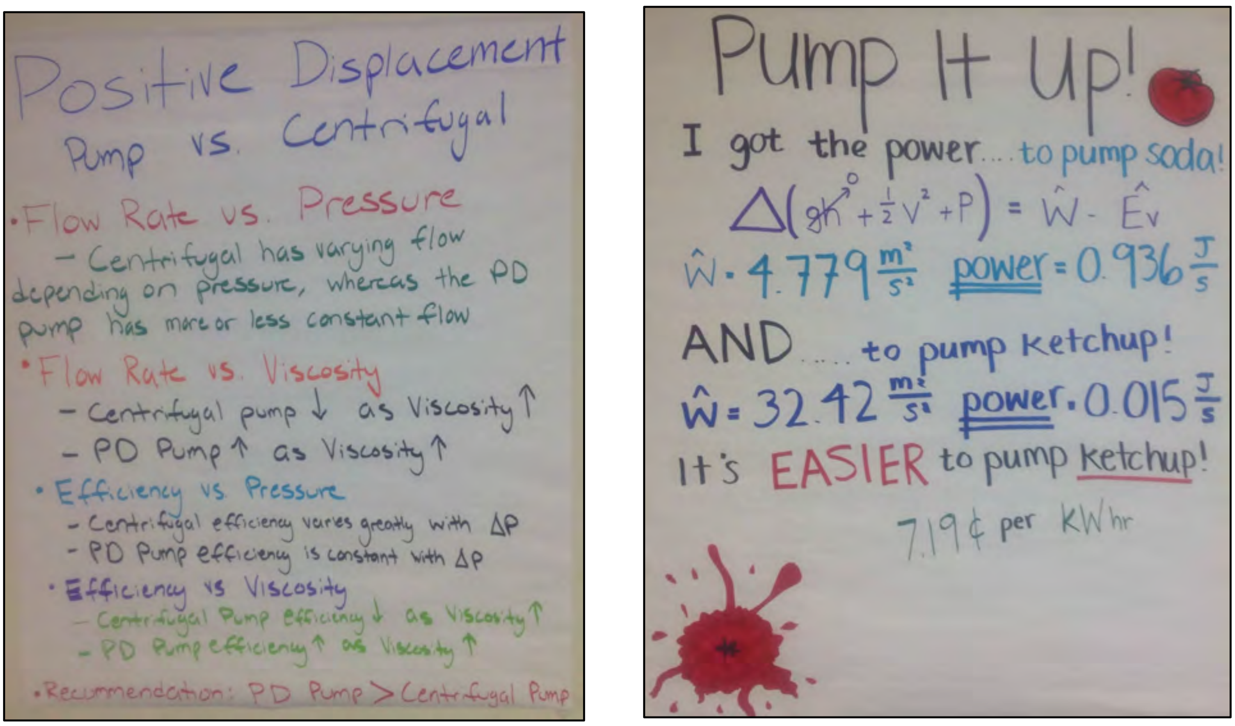

Figure 5. Posters from the Gallery Walk.

6. Assessment of Learning

Table 2 lists the assessment questions and scores from an exam following the PBL module, to measure individual student learning. The questions are listed in order of increasing difficulty according to common definitions of Bloom's Taxonomy levels. The first question, pumping honey, is simply remembering and understanding – making sense of what the student has learned. The second question, barbecue sauce viscosity, applies the information about viscosity in a slightly new way, and the third question requires the students to break concepts into parts and understand their relation: analysing. The students must evaluate information for the fourth question, and the fifth question requires the students to put information together in an innovative way. Thus the questions in the table are arranged in order of increasing levels of learning.

Table 2 Assessment Results

Assessment Question	Average Score	% of students with score above 75%
If you needed to pump honey, what type of pump would you use? Why? Why are centrifugal pumps not used for highly viscous liquids? Sometimes, however, a centrifugal pump is perfect for a shear thinning liquid – why might this be?	95.0%	92%
Barbecue sauce is a nonNewtonian liquid. At 20 rpm, its measured viscosity is 75.2 Pa s, and at 90 rpm, its viscosity is 20.5 Pa s. Estimate its flow behavior index and characteristic viscosity in SI units.	85.4%	85%
A chemical plant needs to pump 100 L/min of ethanol from the bottom of a storage tank, open to the atmosphere, to a packaging plant according to the diagram below. The ethanol has a density of 700 kg/m^3 and a viscosity of 0.8 cP. What power is needed for the pump if it is 70% efficient? The same chemical plant is being used to pump a shear-thinning liquid with K = 2 Pa s and n = 0.7 and the same density. What power is needed now?	91.5%	89%
Sketch a plot of pump capacity as a function of viscosity for both centrifugal and positive displacement pumps.	84.6%	85%
The efflux tank is filled with a shear-thinning liquid. At time = 0, the plug is removed and the fluid starts to exit the tank. What happens to the shear rate during the first few seconds? What happens to the viscosity?	87.2%	77%

As might be expected, the average scores generally decrease with level of difficulty, as does the percentage of students who scored above 75%. However, even as the numbers decrease, the average score is nearly 85% or higher for all questions, and a large majority of the students scored above 75%. The students learned the concepts, even though no formal lectures were provided on the material.

Similar questions were given to the parallel section of the class taught in the traditional way by the same instructor. The average score for question one (pumping honey) was 91.3%, with 91% of the students scoring over 75%. These scores are similar to the experiential learning class. The ethanol pumping question (analysing, number 3) had an average score of 91.7%, and 100% of the students scored above 75%. Again, there is no significant difference between the two groups.

7. Conclusion

The students learned the material through the problem-based learning with the active learning activities interspersed as well as the students taught in the traditional method. A second PBL module following this one covered heat exchanger design, and similar results were obtained. Student evaluations of the course have not yet been received, but comments during the semester were favourable. Problem parameters will be adjusted to make the solution more realistic, but the experiential learning activities work well as designed. For future offerings of the course, links to all information will be provided on the classroom management system so it is available to all students when they need it.

Designing and testing the activities took significant instructor time during the summer before the course was offered. They also required more preparation time during the semester than preparing the traditional lectures. However, the excitement in the classroom and the gains in student learning made it worthwhile.

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Challenge of Teaching Science to Engineering Students

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Abstract: Engineering study is highly dependent on mathematical ability and understanding of scientific principles as engineers apply mathematics and science to solve real world problems. In Australia, Science, Technology, Engineering and Mathematics (STEM) education has been reported to be degrading with time. This paper has shown that all the engineering courses in the University of New South Wales (UNSW) (having one of the largest engineering programs in Australia) have a significant science component, which means that high school leavers intending to undertake engineering studies in UNSW must have a sound background in science. The teaching experiences of two academics in Physics and Fluid Mechanics in Western Sydney University are also presented in this paper; they have noted that poor mathematics and science backgrounds are a major obstacle in completing Physics and Fluid Mechanics successfully by many undergraduate engineering students in Western Sydney University. Few possible solutions to this problem are presented, which include peer learning, development of interactive online tools and offering of short courses to assist the first year engineering students who have not gained enough background in science and mathematics in their high schools.

Keywords: Engineering, Science, STEM, Physics, Mathematics, Fluid Mechanics, Learning

1. Introduction

According to the Oxford dictionary, engineering is defined as "The branch of science and technology concerned with the design, building, and use of engines, machines, and structures." With this definition, the importance of engineering is apparent in virtually every built aspect of our physical environment such as houses, roads, railways, irrigation systems, pipe lines to transport oil, gas and water, cars, aeroplanes and ships. Engineering is traditionally divided into four branches, civil, mechanical, electrical and chemical. Regardless of which type of engineering a student specialises in, the duration of most of the Australian undergraduate engineering courses is four years. As a general overview, within these four years, the first year is spent mainly studying foundation subjects such as science, mathematics, introductory engineering and professional practice.

Engineers implement projects to preserve and enhance environmental and natural systems that support all living beings on this planet. They are concerned with the application of scientific laws and principles to build a better world. Therefore, it logically follows that engineering students need a strong grasp on science and mathematics to be able to understand their relevance and application in real world problems, such as how to reduce the damaging force of flowing water to minimise river bank erosion (needs application of energy and momentum theories) and how to utilise gravitational force as much as possible to manage the water flow in an irrigation system with little/no use of mechanical pumps.

Students entering into the engineering course must have a high level of competence in high school level mathematics and science. However, statistics show that Australia is facing an emerging crisis in the standards of science and mathematics education in her schools, e.g. approximately 40 percent of mathematic classes in years 7-10 are taught by a teacher unqualified in mathematics and the number of students choosing "science" subjects in schools are the lowest they have ever been in 20 years, with Physics being studied by only 14 percent of students in 2010 (Chief Scientist, 2014a). Compared to 1992, there were 30,800 more students in year 12 but 8,000 less students in Physics and 4,000 less in Chemistry (Chief Scientist, 2014b). Physics has been reported to be the least common subject in Australian high schools (Chief Scientist, 2012). From tertiary education data in Australia, it has been found that only 16 percent of university students graduate with a Science, Technology, Engineering or Mathematics (STEM) degree. Although there has been an increase in undergraduate science enrolments in Australian universities, a significant number of students discontinue with science subjects after their first year (Chief Scientist, 2014c). This trend is also true for engineering courses. The dropping standards of STEM occurring in primary and secondary schools in Australia directly flows into the quality of students entering into engineering courses. McDowell (1995) mentions the importance of a solid understanding of foundational knowledge in science and mathematics in order to achieve success in the future. Therefore, it is imperative to acknowledge and address the impact of poor science and mathematics education on engineering and implement strategies to effectively deal with the issue.

In an attempt to restore the decline in standards of STEM subjects in Australia and to prepare for its economic future, the Australian Government has invested in $17 million for STEM. Commencing in primary school, the STEM initiative aims to produce students with a solid understanding in STEM and its application in the real world and to ignite a curiosity in students to continue further tertiary study in STEM related fields. CSIRO has also taken initiative to enhance science and mathematics education in Australian high schools with the aim stated as: "Scientists and Mathematicians in Schools is a national volunteer program bringing real science, mathematics and ICT into the classroom through ongoing flexible partnerships between teachers (K-12) and scientists, mathematicians and ICT professionals". This paper provides an overview of the problems associated with STEM education generally, identifies aspects of science and mathematics education in engineering studies, and suggests a few strategies to overcome these problems in the near future, which could assist in raising the standards of engineering education in Australia.

2. Relationship between Science and Engineering

Science derives its root from the Latin word "scientia" meaning "knowledge; a knowing; expertise". Science focuses on studying the mechanisms and behaviours of the world with the aim of understanding and explaining natural phenomenon. Dealing almost entirely on collecting knowledge and proposing theories, science greatly differs from engineering in this regard as engineers concentrate on the application of established and proven theories into the physical world. Dunn (1930) describes engineering to be "the art of the economic application of science to the purposes of man." However, science and engineering share an undeniable connection as the basis of engineering developments are reliant on the knowledge of science. For example, an engineer required to develop a system to pump water from a river to an irrigation channel in the most energy efficient manner utilises the scientific knowledge on atmospheric pressure, viscosity of water, law of gravity and frictional losses. In solving this real world problem, an engineer makes many simplified assumptions to achieve a solution that could be far from "perfect" in the view of a scientist.

3. **Science Subjects in Engineering Curriculum**

Every engineering degree includes science within its curriculum. Winkleman (2009) mentions how the first two years of contemporary US engineering degrees focus on teaching science before introducing engineering concepts, therefore highlighting the fundamental nature of science in engineering. The University of New South Wales (UNSW) has one of the largest engineering programs in Australia. UNSW offers twenty branches of engineering for their undergraduate bachelor's course: Aerospace, Bioinformatics, Chemical, Civil, Computer, Electrical, Environmental, Geospatial, Industrial, Mechanical, Mechanical and Manufacturing, Mechatronic, Mining, Naval, Petroleum, Photovoltaics, Renewable Energy, Software, Surveying and Telecommunications. It is found that all of these engineering courses in UNSW have at least one compulsory Mathematics course and with the exception of Software Engineering, each of the engineering courses also requires a student to study a first year Physics course. In addition, Bioinformatics, Chemical, Civil, Environmental, Geospatial and Industrial Engineering require students to study at least a first year chemistry course. Bioinformatics is the only engineering specialisation that necessitates the study of Biology courses. Figure 1 shows that Physics is the most commonly studied science subject in the engineering degrees at UNSW. These core science subjects are built upon in further level courses, such as Advanced Thermofluids, which is a third year subject that covers concepts such as heat transfer and exchange mechanism, steady-state and multi-dimensional conduction, structure of boundary layers, internal and external laminar and turbulent forced convection, chemical kinetics and emission control (UNSW, 2016). The scientific principles in these courses are applied in the real world by engineers in a myriad of ways. Table 1 lists a few of the engineering concepts that are dependent on scientific knowledge in the four major disciplines of engineering: Civil, Electrical, Mechanical and Chemical.

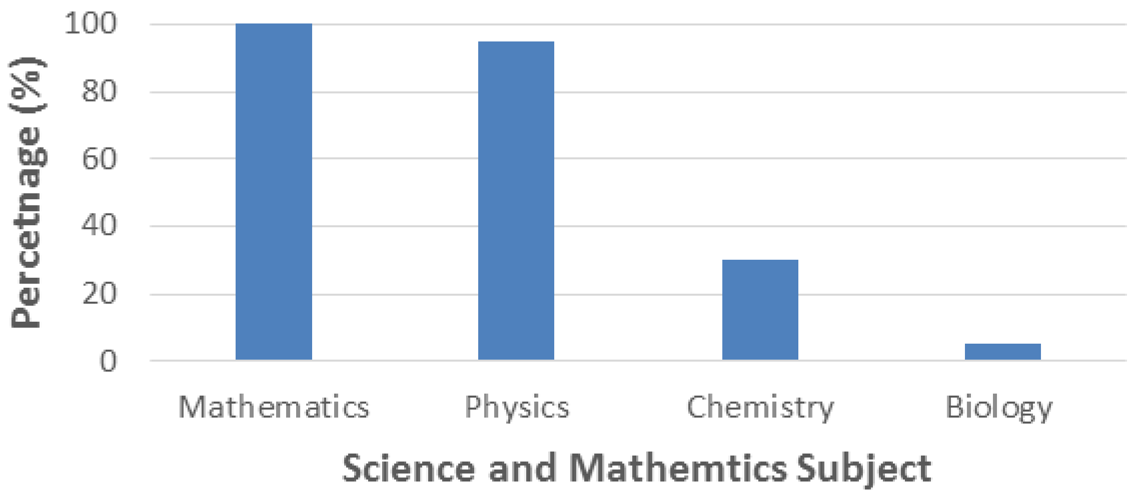

Figure 1 Percentage of individual Mathematics/science subjects included in 20 different types of engineering degrees at University of New South Wales, Australia

4. Problems Faced by Engineering Students in Learning Science

In contrast to Asian countries such as South Korea, Japan, Singapore and India, many engineering students in Australia are weaker in mathematics and hence they struggle to follow the concepts in Physics in their first year of engineering study. In fact, Physics courses at Australian universities have one of the highest failing rates. Low mastery of mathematics also plays a significant role in the inability of a student to excel in many engineering subjects such as Fluid Mechanics and also in applying mathematical models to solve real world engineering problems (Mckagan et al., 2007). Environmental engineering students generally struggle to learn environmental chemistry which is needed in many applications, such as treatment of waste, as many engineering students in Australia do not take Chemistry in high school without which, students have a mediocre or insufficient understanding of fundamental chemical principles such as the balancing of chemical equations, writing of chemical symbols and formulae.

Many engineering students find Fluid Mechanics to be a challenging subject because their understanding on the laws of Physics, such as the principle of buoyancy, energy, momentum and boundary layer concept are not sufficiently developed. Some engineering disciplines have to use stochastic/probabilistic theories, for example the Bayesian theory, Monte Carlo simulation, bootstrapping and joint probability approach. However, for many engineering students these are confusing topics, for example, in statistical hydrology (a civil engineering subject), students often struggle to utilise these principles in an attempt to solve water related problems such as the forecasting of rainfall, wind, flooding and drought.

Table 1 Examples of engineering topics founded directly on scientific principles

Branch of Engineering	Science Subject	Application in Engineering courses
Civil	Physics	Needed in fluid mechanics, hydraulics, statics, dynamics, mechanics of materials and structural analysis.
	Chemistry	Needed in environmental engineering (for example, treatment of waste water, drinking water, solid waste and stormwater, remediation of contaminated soils).
	Geology	Needed for locating appropriate foundations in geotechnical engineering, waste disposal, landfill site selection, nuclear waste burying, selection of materials for construction and examining weathering effects.
	Material Science	Needed to know strength of materials, durability, creep, elasticity, plasticity, liquidity and viscosity.
Electrical	Physics	Needed to understand resistivity, conductivity and magnetism.
	Chemistry	Needed in corrosion of electrical equipment and understanding of super conductors.
Mechanical	Physics	Needed in solid dynamics, fluid dynamics, heat transfer, gravity, friction, aerodynamics, noise, momentum and conservation of mass.
	Chemistry	Needed to control corrosion of moving parts, understand lubrication and fluid behaviour under high temperatures.
	Material Science	Needed to know strength of materials, durability, creep, elasticity, plasticity, liquidity, reactivity and viscosity.
Chemical	Chemistry	Properties of solid, liquid and gases, reaction kinematics and mass balance

5. Reflection of Second and Third Authors in Teaching Engineering Subjects in Western Sydney University

The second author (Dr Ragbir Bhathal) coordinates and teaches Engineering Physics to over 450 first year students at the Western Sydney University (WSU). This is a compulsory foundational subject for all engineering students enrolled in the Bachelor of Engineering degree at WSU. Over the last few years students enrolling in universities in Australia have been coming from a diverse range of educational backgrounds, mathematical and technical skills, prior knowledge and motivations. This is further compounded by the Australian Government's policy of increasing the participation rates of Higher School Certificate students including those from low socioeconomic status (SES) (15.7%) backgrounds (Commonwealth of Australia, 2009; Australian Government, 2016). While this is an admirable initiative it has created problems for universities, especially engineering departments, which rely on students having good backgrounds in Mathematics and Physics. In order to accommodate this change in the knowledge base of the student cohort the author has adopted a multi-strategy approach to the teaching and learning of engineering Physics. This includes: an online Socratic tutorial system (Mastering Physics) in addition to face-to-face tutorials (Young, Freedman, Bhathal & Ford, 2011), using a just-in-time session (10-15 minutes) which revises the relevant mathematics before teaching the engineering topic for the day, an active lecturing system with Q&A and demonstrations, contextual Physics, which shows the relevance of the Physics in an engineering context, hands-on laboratories which have a direct correlation to the theory taught in the lectures (Bhathal, 2011; Bhathal, Sharma & Mendez, 2010). Adopting the above multi-dimensional approach over ten years has led to a decrease in the failure rate of students studying engineering Physics at WSU from 32% in 2002 to 11% in 2014.

The third author of the paper (Associate Professor Dr Ataur Rahman) coordinates and teaches Fluid Mechanics in WSU, which is a second year subject (having enrolments of over 200 students) in civil and mechanical engineering degrees. Fluid mechanics had been a subject with a high failure rate (over 20%) for many years in WSU (Rahman and Al-Amin, 2014). He found that many students studying Fluid Mechanics had basic problems with fundamental concepts in mathematics and science including difficulties in solving simultaneous equations, performing simple differentiations and integrations, conversion of units, understanding momentum and energy equations and deriving basic equations to characterise simple fluid flows. Application of a blended learning technique in recent years involving recorded lectures, use of YouTube materials, on-line access of voice-recorded tutorial solutions and practice quizzes has reduced the failing rate from over 20% to around 10% (Rahman, 2016). Poor mathematical ability has been found to be the main problem in mastering the advanced concepts of Fluid Mechanics. This author also teaches Statistical Hydrology to the third year civil engineering students at WSU; in this subject, he found that a large number of students struggle in grasping the concepts of probability theory, probability distributions and stochastic simulation, which is linked to the weaknesses in mathematics and science of the enrolled students.

Western Sydney University College has been playing an important role in improving science and mathematics skills of the students who do not meet WSU admission criteria directly. These students take foundation courses including mathematics and science to improve their background knowledge for entering into the WSU engineering degrees. This program has been popular at Western Sydney University.

6. Solution to the Problem

The issue of science education in Australia is a nation-wide problem that requires institutional-level intervention to steer it forward. The government has already taken action with the implementation of STEM, but the following suggestions could be of further benefit when applied to the university context, with specific focus on engineering students:

i. Introducing pre-university short courses on science before the commencement of formal first year engineering classes. For example, a 20-hour course on Physics covering the fundamentals of Physics in a simplified manner would be notably useful to first year engineering students. This would be especially helpful for students who have not completed Physics in HSC. Although engineering students who did not study Physics or Chemistry in HSC are required to complete bridging courses in these subjects before the starting of their degrees, these bridging courses are often not emphasised enough or efficient enough in conveying the necessary information.

ii. Forming peer groups consisting of four/five students, two of whom have completed Physics in HSC. Under the supervision of an experienced tutor, these students could be given assessments on the fundamental principles of Physics that are needed in engineering subjects. Active learning that occurs in group work through discussions and questions are widely accepted to enhance learning. In addition, peer groups allow students to more comfortably seek help in problems that they would otherwise be reluctant to go to their superiors for (McDowell, 1995).

iii. Adding a science course in the summer break between first and second year for students who achieve below credit level. This course would allow these students to consolidate their science knowledge by reviewing the knowledge learnt throughout the year.

iv. Offering online tools and compulsory online classes to learn the principles of science subjects under the supervision of experienced academics.

v. Online interactive courses during the offering of the science subjects, under the supervision of trained tutors.

7. Conclusion

This paper presents the importance of science in engineering studies. The poor background in science and mathematics in Australia is a major concern since many engineering students do not have the necessary skills in science and mathematics to complete engineering courses successfully. It has been shown that all the engineering courses at the University of New South Wales (UNSW) have a significant science component, which means that the high school leavers intending to undertake engineering studies in UNSW must have a sound background in science. The teaching experiences of two academics in Physics and Fluid Mechanics subjects in Western Sydney University are presented. They have noted that poor backgrounds in mathematics and science are a major obstacle in completing Physics and Fluid Mechanics subjects by many undergraduate engineering students in Western Sydney University. Few possible solutions are presented, which include peer learning, development of interactive online tools and offering of custom made short courses to assist the first year engineering students who have not gained enough background in science and mathematics in their high schools.

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How to Enhance Technical Writing Skills of New Generation Engineering Students?

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Abstract: Engineers are regarded as problem solvers who use science, technology and mathematics to solve real world problems to build a better physical world. Poor technical writing has been regarded as a significant problem for many engineering students and junior engineers. They are unable to present their new ideas and technical analyses effectively to other people. This paper reviews the issue of technical writing for engineering students in Australia. One possible solution to this problem is the introduction of a new subject in the engineering course curriculum on effective communication similar to some universities in the USA. It is suggested that Engineers Australia prepares a position paper on this issue to investigate the matter in order to recommend a suitable roadmap for implementation that can improve the communication skills of Australian engineering students and junior engineers.

Keywords: Technical writing, communication skills, report writing, project brief, thesis writing

1. Introduction

Engineers play a key role in building a better world by building physical infrastructure, communication system, modes of transport and many other services. They often use complex forms of mathematics and physical and numerical modelling to study system behaviours in providing a sustainable design/solution for an engineering project. Apart from computation/modelling, engineers need to present results of their analyses in a variety of means such as technical reports, theses, project briefs, peer reviewed papers, seminars and workshops to convince decision makers, peers and the general public on many technical problems/projects. This is also important to open the door for feedback from society so that there can be a reciprocal relationship between the needs of society and the problems that engineers solve. It is thus vital for a successful engineer to be a competent presenter and writer as well as a skilled problem solver. It has been reported that engineering students and many junior professional engineers - though very efficient in using communication devices (such as iPhones, iPads and PCs) - often lack in basic writing skills.

Communication skills are an integral aspect of every facet of interaction with people in every walk of life. This is especially true for professionals in the workforce; and though there are varying levels of importance with regards to communication skills across the different spectrum of professions, its fundamental necessity cannot be ignored; tying in with greater proficiency, enhancement and success in any profession. Kohn (2015) alludes to written communication having a high priority in the information age contributing to success in the workplace and promotional opportunities. Employers seek employees with strong writing skills due its role in encoding knowledge and communicating with their customers. Many may have the impression that engineers are amongst the professions where communication is not as important. Poor communication skills are often a concern for senior engineers with regards to junior engineers, complaining of their various shortcomings in this respect.

Steiner (2011) mentioned that although engineers are required to write project proposals and research reports, they seldom receive formal training on effective writing. He also stated that engineers should take extra care to make sure that they avoid ambiguity in their writings so that others are not misinformed. Warnock and Kahn (2007) explained how engineering students often resist writing and stated that they misunderstand the linkage between the thinking process and writing skills. They argued that to implement ideas, engineers must express them in an effective manner so that they are well understood. Reave (2004) presented the results from a survey where she assessed 73 top-ranked USA and Canadian engineering schools, which require a course in technical communication. Only 33% of these engineering schools used a dedicated elective course for improving technical writing of their students, while most other schools used an informal approach integrated with other subjects like professional practice.

Engineers are involved in the planning and completion of many large projects such as railways, bridges, power houses, ship buildings, dams and high-rise buildings. During planning, design, implementation and operation of these projects, engineers must communicate through writing and oral means. The writing aspect includes writing technical reports in presenting particular results, analyses and investigations. Whilst the oral aspect is present during communications with other engineers whilst working on projects and any other parties who are also involved. Communication for engineers generally also encompass drawings, meeting notes, project briefs, emails, text messages and PowerPoint presentations.

The underestimation and misunderstanding of the importance of communication and writing skills is what this paper addresses, identifying the problems and proposing some solutions to enhance the communication skills of engineering students and junior engineers in Australia.

2. Why are engineers poor in communication?

The root of the problem can be traced to engineers having an inherent focus and attachment to mathematics, computations and machineries. This overwhelming focus in these fields leads to engineers neglecting the necessity in developing proficiency in communication. Engineers often also lack basic social skills due to prolonged periods of seclusion and have tendencies to behave like machines. This means they often become frustrated quickly when communicating with peoples of other professions who possess social skills having a much wider vista in understanding the various nuances of human psychology and social behaviour. Most engineering students do not get formal writing lessons and thus they underestimate the need of this aspect of their professional career. For example, based on the study of 243 engineers, Vest et al. (1996) found that these engineers spent more than 50% of their time in communicating with other people in their own or outside organisations.

3. Issues in communication

The common problems that engineers have in their writing include:

1) Having a poor command in grammar, such as incorrect tense, inappropriate or lack of conjunctions, poor spelling and incorrect choice of word selection/phraseology;
2) Language not strong enough: weak vocabulary and poor sentence structures;
3) Struggling to convey ideas smoothly: ideas do not flow through;
4) Poor interconnections between different sections of writings;
5) Writing is too long and convoluted at times;
6) Inconsistency in writing: e.g. references (very common), formatting and titles/headings; and
7) Poor conclusion in summing up the main ideas.

Another area engineers struggle in is their oral communication. They are often lacklustre in communicating ideas and instilling motivation, monotonous during presentations and unable to impart the big picture when explaining a concept. Often there is too much mathematics and equations without sufficient explanations. Whilst in emails the same problem exists in not being able to convey ideas adequately. Sentences often lack structure with incorrect word usage. The tone is often harsh and machine-like, lacking strategy and diplomacy.

4. Successful engineers with great communication skills

Table 1 below lists engineers who have used their communication skills to great advantage to excel in their careers. The list is only a selection of the many successful engineers who have developed advanced communication skills. This table shows that many engineers had high level communication skills which enabled them to serve at a very respectable position in society. This thus indicates that an engineer can also become an effective communicator. This information might encourage junior engineers and engineering students to enhance their communication skills.

Table 1: Engineers holding important positions with great communication skills

Name	Position	Comment on Communication Skill
Sir John Monash (1865-1931)	One of Australia's greatest military commanders. Specialised in new reinforced concrete.	Admired for his articulate communication and had a strong public profile.
Nevil Shute Norway (1899-1960)	Aeronautical Engineer and Pilot and Cofounder of the aircraft construction company Airspeed Ltd.	One of the world's best-selling novelists in the 1950s and 1960s. His celebrity as a writer caused the Ministry of Information to send him to the Normandy Landings and later to Burma.
Roger William Hercules Hawken (1878-1947)	Chairman of the Queensland Institute of Engineers and Secretary of the Institute of Local Government Engineers of Australia. Chair of Engineering and the Office of Dean for 28 years at University of Queensland (UQ).	Wrote many technical papers taking a leading role in the formation of the Institute of Engineers. Lectured at UQ and served as Dean for 29 years. Having wide experience both technically and socially.
Dr. John Jacob Crew Bradfield (1867 –1943)	Engineer in Charge of Sydney Harbour Bridge. A Foundation Member, Institution of Engineers, Australia and Deputy Chancellor, University of Sydney 1942-43.	Prepared reports for Parliament and represented the government in dealings with construction contractors of the Sydney Harbour Bridge.
Alexandre Gustave Bonickhausen dit Eiffel (1832-1923)	The Eiffel Tower in Paris, contribution to building the Statue of Liberty in New York. Conducted valuable research on structural properties of cast iron, made significant contributions to the fields of meteorology and aerodynamics.	Important paper on "The design of Eiffel to the Société des Ingénieurs Civils". Contributed greatly to the science of aerodynamics, Alexander Graham Bell said of Eiffel: "...his writings upon the resistance of the air have already become classical".
Herbert Clark Hoover (1874 –1964)	Began as a mining Engineer starting a mining consulting business, becoming a self-made millionaire several times over before becoming the American President.	31st President of the USA, organized the evacuation of trapped Americans in World War I in Europe, ran the U.S. Food Administration during the war. Wilson relied on Hoover's counsel at the Versailles Peace Conference and as the Director of the President's Supreme Economic Council in 1918. In 1919, he was also instrumental in the negotiation of a treaty with Canada.

José Echegaray y Eizaguirre (1832-1916)	Civil Engineer, Spanish Minister of Public Works and also Finance Minister.	Leading Spanish dramatist, awarded the 1904 Nobel Prize for Literature "in recognition of the numerous and brilliant compositions which, in an individual and original manner, have revived the great traditions of the Spanish drama".
Fyodor Dostoyevsky (1821 – 1881)	Lieutenant Engineer	One of the most widely read and highly regarded Russian writers. His books have been translated into more than 170 languages influencing a multitude of writers and philosophers.
Sir Ove Nyquist Arup (1895-1988)	Led the engineering design of the Sydney Opera House making its construction possible. Founded Arup Group Limited, one of the foremost architectural structural engineering companies of his time.	Formed an international company for communication with governments on public image issues. During the war he published a number of papers on shelter policy and designs.
Stuart Burgess (contemporary)	Professor of Engineering Design, and Head of Mechanical Engineering at Bristol, taught Engineering Design at Cambridge. World expert on Biomimetics (imitating design in nature). Spacecraft design for the European space agency.	Author of several books. Some explaining the significance of design in nature to the public. Contributed to the publication of many science journal articles and conference proceedings.
Lizzie Brown (contemporary)	Named one of Australia's 100 Most Influential Engineers 2013. CEO of Engineers without Borders since 2010. Worked as a Design Engineer for over five years in the water sector in Australia and overseas for companies including OMV Porterra and WRM Water and Environment.	Director of Education in 2006 before becoming the Operations Director in 2009. Awarded a Chief Executive Women Leadership Scholarship and a Churchill Fellowship centred on education, training and research programs for sustainable development in the UK and USA (2006).

5. Experience and reflection on technical writing by the third author (Ataur Rahman) as a student and academic in Australian Universities

This section presents the experience of Ataur Rahman (the third author of this paper) on technical writing as a student and academic. He completed his PhD from Monash University (Australia) in 1996 and then worked as a University Academic in Australia for over 20 years. Since English is not his first language, informal training in technical writing by his supervisory team (consisting of Professor Russell Mein, Mr. Erwin Weinmann and Dr. Bryson Bates in Monash University) assisted him to improve his technical writing standard from a 'limited' to an 'acceptable' level by the end of his PhD candidature. He wrote his first refereed conference paper in 1996 which needed significant guidance by his supervisory panel to reach the desired satisfactory level. However, his second conference paper, written in 1997, demonstrated a distinguishable improvement as noted by his Supervisor Mr. Weinmann. To-date, he has authored over 320 refereed publications and his technical writing skills have been constantly improving since his PhD completion.

Ataur Rahman has supervised over 20 doctoral and 63 Masters, honours and final year engineering project students. These students required writing major/minor theses and/or project reports. According to his subjective judgement, only about 15% of these students had acceptable technical writing skills at the beginning of their candidatures. Most of his Second Year Fluid Mechanics students had great difficulty in writing the literature review part of the laboratory report (Rahman and Al-Amin, 2014; Rahman, 2016). The generic problems in the technical writings of his students are listed in Table 2.

Informal training on technical writing by him to his students mainly via meetings and feedbacks on written drafts have made ‘a difference’ to their technical writings. A good number of his honours students produced excellent theses, e.g. five State Awards were received by his honours students (including the ‘Best Engineering Thesis of the Year Award in NSW State’ on two occasions). His research students have published over 100 referred papers based on their theses during the last 10 years; an exemplification of the sound technical writing skills of his former students. He recognised some of his former students did not achieve acceptable technical writing skills. To overcome these shortcomings, these students would need active industry mentorship to enhance their writing skills.

Table 2 Common problems in technical writing among engineering students in Australia (experienced by the third author)

Nature of problem		
Not thinking well enough before the start – what to write, what the main points are that need elaboration, and how to organise these points in the right order to convey the issue appropriately.	Lack of proof reading.	Do not enjoy their own or others’ writings.
Not preparing structure of the report/thesis/paper in great detail before the start of writing.	Little effort in finding and correcting own mistakes.	Discussion is poor: e.g. lack of enough details of an observation, lack of comparison of the results from similar international studies and issues with the assumptions (how well they are satisfied) and their implications.
Inconsistency in presentation: e.g. in line-spacing, font usage, chapter headings/sub-headings, in-text and chapte-end referencing.	Little effort in becoming a good writer – tendency to write something just for submission to meet cutoff dates.	Criticisms of others’ work without proper justification.
Loose connection among different sections and sub-sections.	Not learning from the best examples.	Unnecessarily long report.
Repetition of facts and figures unnecessarily.	Poor abstract of the report that lacks in important information from the body of the report.	Too long and complex sentences with different parts being poorly connected.
Absence of proper abbreviations at the right places.	Literature review is not critical: e.g. comparison and contrast among existing articles are generally absent.	Use of articles “the”, “a” and “an”.
Improper use of italic fonts: e.g. symbols should be in italic font in a technical document.	There is poor flow of ideas, and readers often have to struggle in comprehending the main focus of the report.	Mixing of past and present tenses inappropriately.
Tables and figures are not mentioned/discussed in the body of the report.	The writing is not focused: e.g. no/little effort in proving/disproving a hypothesis/research question.	Use of capital letters: e.g. poor understanding of proper and common nouns.
Tables and figures are not numbered.	Do not give enough time for writing, and leave it to the supervisor for finalization.	Use of semicolon and comma.

Copying from other sources without rewording and references.	Take criticism negatively, e.g. "My supervisor always criticizes my poor writing, so what is point in improving my writing to improve the writing."	Accepting supervisor's corrections automatically (without going through these): using auto-editing of MS word or similar software.

6. Possible solution

There are no fast solutions in addressing this problem. The following suggestions however, if followed and incorporated, can be a big step in alleviating some of the fundamental issues associated with the communication problem of engineering students. One important step this paper recommends is including, in the duration of a standard engineering degree, 1 subject per year focusing on communication enhancement techniques and strategies/English grammar and stylistic conventions appropriate for the workforce and communicating with professionals. This suggestion would likely cause a dilemma for universities with set syllabuses and subjects, having to potentially lengthen the degree. To address this, it is worth considering either culling a few subjects whose relevance can be scrutinised, or shortening and combining similar subjects, or introducing an elective on communication skills. The current imbalance in engineering curriculums in Australia calls for a serious re-evaluation in incorporating some communication and literary based subjects.

The communication unit in engineering courses should focus on the following steps:

- Early intervention for newcomers who are weak in writing and providing them with a proper learning methodology: form peer-learning groups;
- Limit the use of electronic editing in MS-word, instead do corrections on hard-copy;
- Ensure a proper structure/outline before writing starts;
- Interact with students of other professions who are traditionally good in writing like law and sociology;
- Attend social/general presentations in other schools;
- Model the method of teaching English to the engineering mind where possible (e.g. engineers tend to relate to learning rules, such as rules of grammar and methods of writing);
- Understand the value of communication: can take one to the top of a company: communication is integral; little promotions/career enhancement prospects without effective communication; and
- Make the engineering students aware that they need to influence political and community leaders to initiate mega engineering projects like the Snowy Mountains Scheme in Australia.

7. Conclusion

This paper presents communication issues of Australian engineering students. It has been found that many engineering students lack in writing skills and they do not comprehend the importance of this in their studies. It has been estimated that only about 15% of engineering students, supervised by the third author of this paper have acceptable writing skills at the beginning of their studentships. It is also noted that many engineers rose to a high level in their careers/roles using their great communication and technical skills. To improve the situation of technical writing of engineering students in Australia, a proposal is presented in this paper, which involves the introduction of a new subject on formal communication similar to some universities in the USA. It is suggested that Engineers Australia prepares a position paper on the technical writing issue to investigate the matter in order to recommend a suitable measure for implementation that can improve the communication skills of engineering students and junior engineers in Australia.

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Updating Hydrology Course in Australian Universities: Incorporation of Social Hydrology using a Blended Learning Approach

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Abstract: Understanding the interaction of water with society is vital for achieving sustainable water resources development. There are many water engineering projects worldwide that have provided significant benefits to the community; however, there are examples where ill-planned water projects have undermined the environment and affected the community badly due to an inadequate understanding of the interaction of water with the environment and society. This paper presents an overview of hydrology courses in Australian universities. It has been found that most hydrology courses in Australia are biased towards mathematical computation and there is little focus on inter-disciplinary nature and social aspects of hydrology. A new hydrology course is proposed in this paper to overcome some limitations of the current hydrology courses in Australia. The new course focuses on the interdisciplinary nature of hydrology including social aspects of hydrology, in addition to mathematical aspects. It is proposed to initiate a forum of hydrology academics in Australia to prepare a hydrology course that can meet the need of water industry and research sectors, as well as the need of the society as a whole. A blended learning approach can be adopted to develop such a hydrology course by developing and sharing resources among various disciplines across different institutions.

Keywords: Social hydrology, blended learning, hydrology, water resources engineering, water

1. Introduction

Water is a vital source of life, which affects the well-being of all living beings. Singh (2008) truly stated that "millions of people on this earth live without love and affection, but no one can survive without water even for a few days". Biswas (1970) stated that the history of mankind can be written in terms of human interactions and interrelations with water. In the quest for life in other planets, scientists search for water, which signifies its importance. Hydrology is a subject that studies water for the benefit of the society and the ecosystem for a number of disciplines such as civil engineering, environmental engineering, earth science and geology.

Hydrology covers the variability of water quantity and quality in space and time on earth, encompassing its lithosphere, atmosphere and hydrosphere. To plan and operate an engineering project that deals with water such as water supply, irrigation and flood control projects, one needs to quantify water at a given location in future time (within the life span of the project). The estimation of water quantity needs the use of mathematical equations such as the water balance equation and rational formula, and complex forecasting models. Generally engineering hydrology courses focus on how these mathematical equations can be applied by students to solve a given problem; however, the courses provides little emphasis on societal aspects of water (Rahman, 2016a) e.g. the impacts of water resources developments on society.

The need for an interdisciplinary approach to hydrology education was pointed out by Nash et al.

(1990) and Eagleson et al. (1991) among others. As noted by Wagener et al. (2007), hydrology is becoming 'more interdisciplinary' due to new linkages of this subject with other disciplines (e.g. forest study, environmental science and geoscience) and many recent advances in computational and technical areas. Bourget (2006) showed in a survey of integrated water resources management in the USA that 86% of 600 survey participants noted that there is a great need of watershed hydrology and modelling courses in university (Bourget, 2006).

Hydrology educators are heavily influenced by their background in developing hydrology courses, rather than the need of the industry and society. To develop a contemporary hydrology course, new educational tools and resources should be used in an interactive fashion, using new educational approaches such as blended learning. Bloeschl (2006) noted that advancements in hydrological science are likely to arise from the synthesis of different approaches, from 'collision' of theory and data, and from better communication. As noted by Wagener et al. (2007) the first step in developing a new interdisciplinary hydrology course should be based on wider consultation among educators and practising hydrologists and that it "begins with examining the current state of hydrology education, who is teaching, in what department/disciplines, and with what materials". In this context, this paper examines the hydrology course contents of a number of Australian universities and proposes a hydrology course that can meet the demands of all the stakeholders, including the society and ecosystem.

2. Overview of hydrology education in Australian universities

In Australian universities, hydrology is offered as a subject, generally in the third year of undergraduate engineering degrees. It has the prerequisite of Fluid Mechanics or Water Engineering which cover the basic principles of fluid flow including fluid properties, energy and momentum principles, basic open channel flow and dimensional analysis. As shown in Table 1, Hydrology subjects generally contain the following topics: water balance, hydrograph analysis, runoff routing, flood routing, flood frequency analysis and design rainfall estimation. In some universities, groundwater is included as a small chapter. Social Hydrology is not included in the hydrology subject of any Australian university. This paper presents justification of including social hydrology topic in the hydrology syllabus.

3. Importance of incorporating social hydrology into hydrology course

Water underpins sustainability of the environment. A hydrologist must know the implication of a water resource development project on the environment such as how the environment and the society in the dam catchment will be affected if a dam is built across a river for irrigation or hydro-electricity generation (e.g. how many people could be displaced and how their lives will be impacted). The changing of landscape for a new water resources engineering project may require land clearing, which can exert notable impacts on water-cycle dynamics at local to regional and decadal to century time scales. A hydrologist/water engineer should appreciate the impacts of such water resources engineering project on the society at a local, regional and global scale.

Some of the water engineering projects are very large and can affect the society and ecosystem on a significant scale. One example is the Snowy Mountains Scheme in Australia that consists of sixteen major dams, seven power stations and 225 km of tunnels, pipelines and aqueducts. This project was implemented between 1949 and 1974 and is considered to be the largest engineering project ever undertaken in Australia. This project is regarded as an Australian identity signifying its resources and potential as a powerful country. This project generated significant employment and benefited the Australian society after the Second World War. As a hydrologist, one should appreciate the impacts of such a huge project on society and how its failure can affect many people in a many different ways. In this regard, social hydrology is receiving attention from many new generation, hydrology researchers and academics.

In the above context, Sivapalan et al. (2014) noted that social hydrology considers the impacts of decentralized human agents and institutions to water flows and storages, as well as their feedbacks. Zlinszky and Timar (2013) stated that social hydrology "is the science of human influence on hydrology and the influence of the water cycle on human social systems". Social hydrology deals with the understanding of the dynamics of coupled human water systems over spatial and temporal scales that are large (Srinivasan, 2015). The above definitions of social hydrology indicate that it focuses on water over a large scale in space and time, and without a broad understanding of social hydrology concepts, hydrologists and water engineers may not be able to act appropriately to preserve and enhance water resources for a balanced and sustainable development for the present and future generations.

There are many examples where a poor understanding of the interaction of water with the environment and society has caused dreadful consequences. An example is the Polder Project in the coastal areas of Bangladesh, which attempted to build earthen embankments to create new lands for agricultural developments during the 1960s and 1970s. Approximately after 20 years of the construction, many of these polders badly failed and caused a serious water-logging problem. One of these polders is Beel Dakatia, located in south-western Bangladesh. The polder has become an inland sea due to heavy siltation in the outfall river system that prevents natural drainage. This has caused a serious problem in the socioeconomic condition of the region by causing the collapse of agriculture, livestock and social infrastructure. Figure 1 shows how the Beel Dakatia region has become a natural disaster zone with permanent water logging.

Sivapalan et al. (2014) noted that there are examples of "wicked" water resources engineering projects causing a great concern such as trade-offs among ecosystems, hydropower, and livelihoods in the transnational Mekong Basin (Ziv et al., 2012), increased dry land salinity in Australia, expansion of hypoxic zones in the Gulf of Mexico due to higher nutrient loading in the agricultural lands of the Mississippi River (Turner and Rabalais, 2003) and 'bad politics' around water sharing issues for numerous national and international rivers (Gleick, 1993).

Figure 1 Beel Dakatia in South Western Bangladesh where water-logging has made thousands of hectares of agricultural land unsuitable for cultivation

Table 1 Hydrology course outline in some Australian universities

University	Course name	Course content
University of New South Wales	CVEN9610: Surface Water Hydrology	Hydrologic cycle; climate and weather; meteorological and hydrologic measurement; evaporation and evapotranspiration; rainfall/runoff processes including loss models and hydrograph analysis; design rainfall; data and flood frequency analysis; flood estimation including regional methods and estimation of extremes.
University of Sydney	LWSC2002: Introductory Hydrology	This unit introduces students to hydrology and water management in the context of Australian integrated catchment management. It particularly focuses on the water balances, rainfall runoff modeling, analysis and prediction of streamflow and environmental flows, water quality and sustainable practices in water management.
Monash University	CIV5882: Flood hydraulics and hydrology	This unit focuses on flood modelling for engineering design. Methods to estimate design flood magnitudes from experimental observations will be presented. Hydrologic and hydraulic routing models will be introduced along with software packages that apply these models.
Western Sydney University	300766: Surface water hydrology	The unit covers the principles of surface water hydrology. It will focus on catchment analysis, specifically focusing on rainfall-runoff relationships. Successful completion of this unit will enable hydrologic analysis of catchments to satisfy various regulatory requirements.
University of Technology Sydney	48362: Hydraulics and Hydrology	The objective of this subject is to give students knowledge of open channel hydraulics and hydrology, leading to understanding of the scientific foundations and basic principles of these fields, and the ability to apply hydraulic and hydrological methods to engineering applications in an integrated way. … hydrology – the hydrological cycle, water balances, meteorology and climatology, data collection, statistics, hydrological models, design rainfalls, rainfall-runoff processes, flood estimation models and procedures, software packages, yield analysis, groundwater, environmental hydrology; and integration of hydraulics and hydrology case studies.
Griffith University	2004ENG Hydrology	The course covers fundamental hydrologic processes such as rainfall, evaporation, infiltration, surface and ground water, and hydrologic extremes ie floods and droughts … flood estimation, flood frequency analysis, and flood routing.

4. A proposed outline of hydrology syllabus in Australian university

In this paper it is argued that hydrology courses in Australia should not focus merely on mathematical aspects of hydrology; rather, it should be designed as an interdisciplinary subject. It should have a chapter on social hydrology to make the students aware of the broader implications of water engineering projects on society at large, and how the spatial and temporal distribution of water quantity and quality can affect the ecosystem and human beings across local, regional, national and international domains. According to Sivapalan et al. (2012) social hydrology should include three fundamental sub-areas (i) Historical Social Hydrology (to know history of hydrology, success and failure of past hydrology schemes; (ii) Comparative Social Hydrology (comparative analysis of human-water interactions across socio-economic and climatic gradients to map spatial and regional differences back to processes and their temporal dynamics; and (3) Process Social Hydrology (focusing on a small number of human-water systems in greater depth including data collection and modelling covering hydrological and social processes). Any new hydrology course that includes social hydrology should consider the above aspects as outlined in Table 2.

Table 2 Outline of a proposed hydrology course in Australian universities

Week	Title	Topics
1	Hydrologic cycle	Interaction among various components of the hydrologic cycle, water quantity and quality aspects, water balance modelling and examples of hydrologic projects such as Warragamba reservoir and Snowy Mountains Engineering Scheme. Introduction to Australian Rainfall and Runoff.
2	Rainfall and runoff measurement	Measurement of rainfall and streamflow data, relative accuracy of measured data, rating curve construction and associate uncertainty, and spatial and temporal measurements of rainfall.
3	Design rainfall estimation	Design rainfall estimation, areal rainfall and temporal patterns of rainfall. Use Australian Rainfall and Runoff to obtain design rainfalls for any given location of Australia
4	Runoff estimation	Empirical methods (Rational method and regional flood frequency analysis: RFFE Model) and loss modelling
5	Unit hydrograph	Unit hydrograph calculation.
6	Runoff and flood routing	Flood routing and demonstration of RORB model.
7	Urban hydrology	Impacts of urbanization on water cycle. Demonstration of DRAINS model.
8	Flood frequency analysis 1	Probability concept, Normal distribution, Log Normal distribution and LP3 distribution.
9	Flood frequency analysis 2	L moments and GEV distribution, Demonstration of R program, and demonstration of FLIKE software.
10	Groundwater hydrology	Aquifers, basic groundwater flow, well hydraulics and interaction of surface and groundwater.
11	Social hydrology	History of hydrology, case studies on success and failure of large water engineering projects and the interaction of water and society through examples.
12	Impacts of climate change on water	Trend analysis and non-stationary frequency analysis.
13	Future of hydrology	Remote sensing and integrated hydrologic modelling. Demonstration of Australian Rainfall and Runoff and its previous, current and future revisions.

Table 1 shows that hydrology courses in Australian universities are heavily focused on mathematical aspects of the subject. A new hydrology course is proposed in Table 2 that focuses on the inter-disciplinary nature of hydrology plus the demonstration of industry-based models and Australian Rainfall and Runoff (National Guideline). It is proposed to initiate a forum of hydrology academics in Australia to prepare a hydrology course that can meet the needs of the water industry and research sectors. A blended learning approach (Rahman, 2016b) can be adopted to develop the course materials using internet-based resources including video clips, recorded lectures, recorded tutorials and online discussion. Shareable resources can be developed by a collaborative approach among departments like Civil Engineering, Earth Sciences and Geography across various universities.

5. Conclusion

This paper presents an overview of hydrology courses in Australian universities. It has been found that most of the hydrology courses in Australia are biased towards mathematical aspects of the subject. There is little focus on the big picture and the inter-disciplinary nature of hydrology. Social hydrology is absent in the hydrology syllabus in most of the Australian universities. A new hydrology course is proposed in this paper, which can overcome some of the limitations of the current hydrology course in Australia. The new course focuses on mathematical aspects, demonstration of software and the interdisciplinary nature of hydrology, including social aspects of hydrology. It is proposed to initiate a forum of hydrology academics in Australia to prepare a hydrology course that can meet the need of the water industry and research sectors, as well as the society as a whole.

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“The collaborative learning with PBL or Flipped Learning. Case of Engineering Drawing Course."

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Abstract: The course of Engineering Drawing is a new way where the latest approaches and tendencies about learning appear because the learning ways has been changing from an expositive to an active -participative methodology and finally to use the PBL method.
By this way, as I see, the students introduce basics concepts through a collaborative work called Flipped Learning. But, they are just technological changes from the essential collaborative learning by ABP.
The Flipped Learning is in fact like to go from the collective to the individual learning, getting a dynamic space for an interactive learning where the teacher guides students meanwhile they apply concepts and creative participation is allowed in the same way as on the PBL where several tools are used and after a group process they find the answer been guide by the teacher.
In the ABP method the teacher guides the students, making easier the way to solve the problem. I think that the only change is the use of Videos as a help for individual learning out of class and not the solution for a real problem where students must search the answer being guide by the teacher.

Keywords: PBL, Flipped Learning, Collaborative Learning, Engineering Drawing

1. Introduction

The course Engineering Drawing is an example where new trends or approaches to learn appears: As it has been transformed over the years with various changes that has been applied, from an expository methodology (lecture), then make changes using a job active-participatory teaching and finally use the PBL.
For that experience I can say that students incorporate the basic elements through a collaborative work, that in this moment many people call Flipped Learning, but for my optical point of view are merely technological changes in the essential form of collaborative learning with PBL.
Flipped Learning goes from one instruction that moves from the space of collective learning into space of individual learning resulting in an interactive dynamic space to learn in which the educator guide students as the concepts will apply and can participate creatively in the field, as the same way that PBL is done, because it started from a real problem where the students group investigates individually under multiple tools and then a group process responses to a problem with the help of the teacher as guide sought.
The basis of collaborative learning with PBL where the teacher is a facilitator are similar to those pillars showing called Flipped Learning are flexible environment, creating a learning culture, targeted content and professional facilitator. The only new thing is the use of video as support for self-directed learning outside the classroom and not creating a real problem where the student must investigate and look more openly guided by the facilitator solution.

2. The Drawing Course

The Engineering Drawing Course, offered in the General Studies - Science (EEGGCC) at the PUCP, is mandatory for all major programs and is taught using collaborative learning methodology and PBL, in some sessions. Its content is the result of the restructuring made in 1998. It was when two courses merged: Drawing and Descriptive Geometry 1 and Drawing and Descriptive Geometry 2. Such resulting course was taught by lecturing. This change was made soon after the creation of the majors in Electronic, Telecommunications and I.T. So far, three more major programs have been created: Geological Engineering, Telecommunications and Mechatronics.

Due to the time passed, such course needs to be revised and updated considering the different major programs and new methodologies.

3. About the ENGINEERING DRAWING course

Currently, it has three hours of theory, two hours a week of guided practice as well as two lab hours and two hours for tests, both biweekly. Theory combines the lecture with the participation of the students. For this, the professor has the support of teaching assistants (TA). The course consists of:

- Theory (3 hours per week): Professor and 2 assistants for each class of 64 students.
- Guided Practice (2 hours per week): Professor and two assistants, who advise students on the drawings of different sheets.
- Tests (2 hours/biweekly): Students are not advised. They are evaluated on what has been learned, the skill, dexterity and speed.
- Laboratory (2 hours/biweekly): The student receives basic knowledge on the operation of the software and then puts it into practice. It has four TAs for each group.

Currently, theory classes are made for 64 students in charge of a professor and two TAs. For guided practice, it is necessary to have 20 students per TA, in other words, 2 TAs and the professor for each group of 64 students. For Tests, 2 TAs are needed as well as 2 TAs who answer questions during the evaluation.

In the laboratory, according to the Regulations, one TA is needed for every 12 students. This means that 4 TAs are necessary per group, divided in two lab groups which means 32 students per commission with 2 TAs per commission.

4. Analysis of the course

After analyzing the content in accordance with each of the majors, it is concluded that a unique course for all engineering programs should be offered. In that sense, it cannot study in depth any of them, but must meet the basic and fundamental needs of each one at the graphical representation level as a means of communication between technicians and engineers.

The course requires continuous practice by the students. Therefore, it currently asks for their active participation during theory sessions. Moreover, the participation of teaching assistants in the theory sessions is required in order to achieve the desired objectives.

To assess the student's learning and his capacity and skills in technical drawing, assessment sessions are needed. Some of them may have counseling to strengthen the theoretical aspects and others without it to evaluate learning.

It is necessary that, in addition to the manual drawing with tools, students use some drawing software. Students are not expected to master the software at the end of the course.

5. New rules

With the new regulations, courses should be adjusted and, therefore, shall not have the support of TAs for theory. This means that it is almost impossible to teach them theory and make them practice with a single teacher per classroom. This is why we, as professors, are looking cautiously for a methodology that could be adapted for a participatory active course, massively and without teaching assistants. This is why we will opt for applying a combination of Flipped learning and lectures, but more actively in the theory part but having the support of tutorial videos. With this, we hope students will be able to do their homework and keep the collaborative active methodology in the Guided Practices.

6 A new methodology or an adaptation?

As previously mentioned, the Engineering Drawing Course comes from two courses and the topics cannot be taught in two hours or less. Especially if active participation techniques are to be used and needed along the course.

The foundations of collaborative learning with PBL, where the professor is a facilitator, are similar to the pillars shown by the so called Flipped Learning. These are the flexible environment as well as creating a learning culture, a directed content and a facilitating professional. The innovation is the supporting videos aimed at self-learning outside the classroom and not on the creation of a real problem where the student must research and find, more openly, the facilitator-guided solution. It is also important to reflect on the time/credit that the student will take to see and get to analyse the tool outside the classroom.

7. Final decision

For these reasons, we have decided to try this mixture of methodology as a pilot project to create a methodology that fits our requirements. Also, we want to see if students can deal with the idea of achieving prior learning before each theory class

8. Conclusions

This proposal for a change, is really an adaptation, that we will be doing next semester, and is through this pilot project that will give us light, if it is feasible or not to make the changes that we are suggesting.

For developing the corresponding adaptations due to the restrictions indicated, we will use the Power Point presentations we have and turn them into supporting videos for moderating theory. For this, we will use the free program Sreencast- O-Matic as support for creating them. Subsequently, we will post them on the course BLOG we are creating for helping of all the students.

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Adding Practice to Theory: Using Chevron Phillips's Tenets of Operation to Analyse Case Studies in Engineering Ethics

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Abstract: Undergraduate Engineering Ethics units often draw from case studies of historical disasters or accidents in order to evaluate engineers' decisions prior to, during, and after a crisis. Students also examine engineering ethics codes and consider whether the engineers or managers in the case study maintained such values as "to hold paramount the safety, health, and welfare of the public." Yet in many such studies, the conclusion that engineering ethical codes were violated appears obvious, and students miss an opportunity to examine the deeper relationship between an engineer's ethical or unethical behaviour and the larger workplace culture that enabled it. For undergraduates heading for leadership positions in industry, understanding the dynamics of that relationship could support their future ability to cultivate a safe workplace. This paper presents one way a Chemical Engineering undergraduate ethics unit makes use of Chevron Phillips's Tenets of Operation, which are clear and specific guidelines for behaviour in potentially hazardous situations, both in and beyond industry. A writing assignment offers the Tenets as criteria of evaluation for analysing a range of industrial and laboratory accidents. When used in tandem with Engineering Ethics codes, the Tenets enable students to examine closely the behaviours that led to accidents, or, in some cases, avoided them. Thus, engineering safety becomes a matter of daily practice as well as the paramount principle for ethical conduct as a professional engineer.

Keywords: Engineering Ethics, Chevron Phillips Tenets of Operation, Case Studies

1. Introduction

In 2007, runaway reactions at T2 Laboratories Inc., a small chemical manufacturer in Jacksonville, Florida, caused an explosion the size of about an imperial ton of TNT (CSB, 2009a). Four employees, including one owner, were killed and another four injured. The plant was destroyed. The blast force hurled debris as far as a mile and broke windows in nearby businesses, injuring twenty-eight members of the public (CSB, 2009a). Emergency responders rushed towards an exceptionally dangerous site: the Jacksonville Fire Chief described it as a "worst case scenario" with "multiple types of chemicals...all mixed together and all burning together" (CSB, 2009b).

The runaway reactions took place during T2's production of methylcyclopentadienyl manganese tricarbonyl (MCMT), a petroleum additive sold under the name of "Ecotane"(UCSB, 2009, p. 6). MCMT is combustible, toxic, and considered "extremely hazardous" by the Environmental Protection Agency (EPA, 2016). T2 had been manufacturing MCMT since 2004, and the explosion took place during Batch 175 (CSB, 2009, pp. 4-6).

The Investigation Report on the disaster from the U.S. Chemical Safety Board (CSB) (2009a) raised multiple concerns, among them the training and education for Chemical Engineers responsible for reactive chemical processes. As the CSB chairman, John Bresland, stated: "This was a tragic, unnecessary loss of life... it is vital that companies are acutely aware of potential hazards" (Patterson, 2009). One co-owner of the plant, killed in the blast, had held a BS in Chemical Engineering; his business partner was a Chemist. Yet neither owner had the training or experience necessary to design and manage the scaled-up reactive process that led to the explosion (Patterson, 2009; CSB, 2009a). Consequently, the CSB urged the American Institute of Chemical Engineers (AIChE) and the Accreditation Board for Engineering and Technology (ABET) to require better education for undergraduate engineers in reactive chemical hazards and process safety analysis. Since 2012, ABET has required accredited Chemical Engineering departments to incorporate process safety education into their undergraduate curricula (CSB, 2012). The T2 tragedy now appears as a case study in process safety textbooks such as Crowl and Louvar (2011).

This enhanced emphasis on process safety training in Chemical Engineering dovetails with engineering educators' increased investment in ethics instruction since ABET established its Engineering Criteria 2000 as discussed by Herkert (2002). Like the process safety units, many engineering ethics course materials employ case studies, evaluating engineers' decisions prior to, during, and after a crisis. Students also examine engineering ethics codes and use them as criteria to evaluate whether the engineers in the case studies maintained such principles as the first canon (or paramountcy principle) of the AIChE code "to hold paramount the safety, health, and welfare of the public and to protect the environment in the performance of their professional duties" (AIChE, 2016).

The author teaches such an ethics unit to Chemical Engineering undergraduates at The University of Texas at Austin. Yet when the students first ran an ethical analysis of the T2 case and others related to process safety, the conclusion that engineering ethical codes were violated was obvious. The assignment needed a more rigorous means for students to examine the deeper relationships among an engineer's ethical or unethical behaviour in an environment demanding high-risk management, the workplace culture that enabled such behaviour, company leadership, and external pressures from communities and government regulatory agencies. For students heading for leadership positions in industry, understanding the ethical dimensions of those relationships could support their future ability to cultivate a relatively safe workplace, to better protect their co-workers and surrounding communities.

A guest speaker from industry, Michael Zeglin from Chevron Phillips Chemical Company LP (CPChem), offered a refinement to the assignment's criteria of evaluation. Zeglin's lecture and discussion introduced the UT, Austin students to CPChem's Tenets of Operation, a code of conduct to be followed in high-risk environments. When CPChem was founded in 2000, it adopted the Tenets program to improve plant safety after a series of major accidents in the industry (Wood, 2004). For most years since 2001, the Tenets program has enabled CPChem to reduce its recordable injury rate with the Occupational Safety and Health Administration (OSHA) to within the American Chemistry Council's top 25% (Zeglin, 2011).

Although the Tenets are not ethics codes, their emphasis on worker safety and reducing accidents, which affect public safety, aligns with the AIChE, ABET, and other engineering codes. Moreover, the Tenets are general enough to apply beyond one industry's domain: this feature suggested that undergraduate engineering students could incorporate the Tenets as an analytic tool to assess how engineers handled decisions in a range of risky situations.

When the UT students analysed process safety case studies combining an ethics code and the Tenets, the specific behaviours that contributed to unethical actions and resulting accidents came into focus. The Tenets link the theoretical realm of the engineering codes with the daily practical needs of working engineers who must make informed decisions about risk within a limited time frame. This paper describes the course assignment, followed by a brief history and description of the Tenets of

Operation. It then offers an example of how the Tenets were used to enrich two students' ethical analysis of the T2 Laboratory case study, and to acquaint them with one effective program for improving safety in the industry they would soon join.

2. The Ethics Report Assignment

The ethics unit described here features in an Engineering Communications course taught in UT Austin's Dept. of Chemical Engineering. The course is one of several that meet departmental, school, and university requirements for ethics and writing. Most Engineering Communications instructors hold humanities or social science degrees, so students must make technical material clear for non-technical audiences. In the ethics unit for the Chemical Engineering class, a major research paper (the Ethics Report) and presentation evaluate the ethics behind a company or government organization's crisis. With some constraints, students may select their own topics, but many draw from the CSB final investigations. Students may encounter case studies like that of T2 Laboratories in other engineering coursework, so they have the opportunity to complement the Ethics Report with technical training in reactive hazards and process safety.

The course uses Michael Davis's foundational essay "Thinking Like an Engineer" (1998) as a introduction to engineering ethics codes: Davis highlights the ABET ethics code's paramountcy principle, examining its necessity, analysing its terms, and discussing engineers' responsibility to uphold and promote it. Then, students select a case study and employ the ABET, AIChE, or other appropriate ethics codes as criteria of evaluation to consider whether the engineers in question indeed acted to protect the safety of the public (and environment), among other obligations. With some case studies, however, the ethics code works most effectively when paired with a more specific code of behaviour or decision-making, such as CPChem's Tenets of Operation.

3. CPChem's Tenets of Operation

CPChem was formed in 2000 from two parent companies, Chevron and Phillips Petroleum with the Tenets of Operation as the foundation for decision-making and its operating philosophy. The Tenets originated with Chevron after failed efforts to reduce incidents and improve plant safety (Buell, 2006; Zeglin, 2011). A version of the Tenets appears on Chevron's website (Chevron, 2016). Working with third-party consultants, Chevron derived the Tenets by analysing incident investigation data and affinity grouping the common principle violations (Buell, 2006; Zeglin, 2011). In analysing their incidents, Chevron found that their "incident costs" rose exponentially with the number of Tenets violated (Zeglin, 2011). This insight exposed the false economy of cutting corners under the pretence of saving time and money.

The chemical industry uses OSHA's Recordable Injury Rate (RIR) as one means to gauge safe work practices; by this standard, the Tenets program improved CPChem's safety culture. In 2000, CPChem's RIR was 1.23, outside the boundary of the American Chemistry Council members' top 25%. After four years of developing and training employees in how to use the Tenets, CPChem achieved an RIR low enough to place the company within the top 25%. By 2010, its RIR was much-improved .44 (Zeglin, 2011).

The Tenets draw from three principles: "Work safely or not at all"; "There is always time to do it right"; and "If it's worth doing, do it better" (CPChem, 2016). These principles supersede the common industry mantra to work "better, faster, cheaper."

The Tenets themselves are specific behavioural guidelines shown in Table 1.

Table 1 The Chevron Phillips Chemical Company's Tenets of Operation (Zeglin, 2011)

1. Never operate equipment or tanks outside of design or environmental limits.
2. Always move to a safe, controlled condition and seek assistance when a situation is not understood.
3. Always operate with safety devices armed.
4. Always follow all safe work practices/procedures and act to stop unsafe conditions and actions.
5. Always produce a product that meets or exceeds your customers' requirements.
6. Never contaminate or compromise a dedicated system.
7. Always report environmental/safety compliance information accurately and on time.
8. Always address abnormal conditions and clarify/understand procedures before proceeding.
9. Always follow written procedures for high risk or unusual situations.
10. Always involve people with expertise and first-hand knowledge in decisions, improvements, and changes that affect procedures and equipment.

The Tenets' clarity belies the challenge of putting them into practice. In addition to affirming that safety is worth the investment, the Tenets program asserts that "all employees are empowered to act" (Zeglin, 2011). "All employees" means just that. Buell describes the Tenets as a "living part" of Chevron's company culture, extending from "senior leadership to front line supervisors and to the entire workforce" (2006, p. 4). Maintaining a safe company culture requires that the Tenets be posted about the company premises; employees receive "tenet cards" for wallets. Tenet leaders run frequent group discussions of incidents and their root causes, referencing the Tenets as standards (2006).

Although the Tenets address behaviour rather than ethics, they contribute to discussions of how engineers, as members of a profession, can decide whether taking a particular risk is ethical. Ross and Athanassoulis (2010) find no "clear formula", but call for a set of "public, profession-endorsed standards by which decisions regarding risk in an engineering context can be judged" (p. 167). The Tenets offer a set of standards taken by one company to make such decisions, as noted above, in a workplace that discusses the standards thoughtfully and often (Buell, 2006; Zeglin, 2011).

Because the Tenets can apply to situations beyond chemical plants, students readily find potential applications in their laboratory classes and daily lives. In Ethics Reports, they may practice a version of Tenet group discussions. Students first examine what occurred during their case study, drawing primarily from CSB Investigation Reports. They next observe what actions or behaviours contributed to the crisis. Finally, they compare those actions and inactions to the Tenets. Depending on their scope, students may also examine external forces, such as the role of OSHA in their case study.

4. The T2 Laboratories Explosion

CSB Reports generally provide students with incident descriptions, company background, equipment and process details, external factors like the role of government agencies, and root cause analysis. The T2 Report concludes with Recommendations, including that ABET require "reactive hazard awareness" in Chemical Engineering curricula (2009a, p. 41). Its root cause analysis states that "T2 did not recognize the runaway hazard associated with the MCMT it was producing"; the analysis also specifies two contributing causes in the plant equipment design and settings (p. 48).

4.1 Neglect of reactive hazard awareness prior to explosion

The T2 Report's company background reveals the owners' historical neglect of process safety. Founded in 1996, T2 Laboratories originally blended printing solvents and "pre-manufactured" MCMT. Four years later, responding to a client request, they decided to manufacture MCMT themselves (CSB, 2009, p. 17). The owners developed a production process by hiring consultants and running laboratory tests based on patents, which describe the chemistry but not the process hazards (CSB, 2009, pp. 25, 34).

T2's production process for MCMT involved three steps. The disaster occurred during the first step, called "metalation." In this step, metallic sodium was added to a mixture of methylcyclopentadiene (MCPD) dimers and diethylene glycol dimethyl ether (diglyme). The application of heat caused a reaction that created sodium methylcyclopentadiene, hydrogen gas (vented), and heat. This "desired exothermic reaction," required cooling, as did the later two steps (2009a, p. 46). An early consultant advised T2 to perform a Process Hazard Analysis, which identifies conditions that could lead to a runaway reaction. However, they did not take this counsel, and missed that high temperatures at metalation could start a second, "undesired exothermic reaction" (CSB, 2009a, pp. 35, 47). Therefore, in January, 2004, T2 unwittingly carried at least one potential hazard from the laboratory into full-scale production (CSB, 2009a, pp. 18, 25).

Problems emerged in the first, full-scale batch, when an "unexpected exothermic reaction" occurred during metalation. T2 adjusted the batch recipe, but similar events occurred during two of the next several batches. In response, T2 changed the recipe or adjusted the process. They did not examine the potential causes of the "unexpected" reactions. Instead, with Batch 11, T2 initiated commercial production, and with Batch 42 (mid-2005) they scaled up the size by one-third, again without investigating hazards (CSB, 2009a, pp. 18, 26-28). Thus, despite a warning and signs of danger, T2 not only started a hazardous commercial process, but also scaled it up without sufficient precaution.

4.2 The explosion

On Dec. 19, 2007, T2 began its poorly-understood production of Batch 147 in old plant equipment. All steps took place in a refurbished reactor built in 1962. The gas was released via a vent line with a rupture disc set at 400 psig and, at the reactor top, a pressure control valve. In a control room nearby, a process operator managed the reaction. Outside, by the reactor, other operators assisted. First, the process operator mixed the MCPD dimer and the diglyme liquids in the reactor. Next, an outside operator added the metallic sodium. The process operator applied heat until the reaction temperature reached 300°F (148.9°C). Then he removed the heat and watched the temperature until it reached 360°F (182.2°C), when he started the cooling system (CSB, 2009a, pp. 21-22).

Instead of cooling, however, the reactor's temperature rose, starting a second exothermic reaction at slightly above 390°F (198.9°C) (CSB, 2009a, p. 25). The process operator summoned the owners. Soon after arriving, one owner left to find a mechanic and the other worked with the process operator, ordering outside operators to leave the area in case of fire. Ten minutes later, the cooling and venting systems failed, the reactor burst, and chemicals exploded, killing one owner, the process operator, two outside operators, and injuring thirty-eight other people (CSB, 2009a, p. 12).

4.3 Contributing causes

The CSB faulted the reactor's cooling and gas venting systems as "contributing causes" to the disaster. The cooling system drew from city water piped to the reactor via a valve and a connecting pipe. The process operator "intermittently injected" water into a reactor jacket, where it boiled. Resulting steam was released through an open pipe (CSB, 2009a, pp. 19, 22). The CSB noted that this simple cooling system lacked design redundancy; operators had no ready access to additional water in an emergency (pp. 22, 39). Worse, surviving employees told investigators that T2 "ran cooling system components to failure and did not perform preventive maintenance" (p. 24). The CSB also investigated the gas venting system, specifically the rupture disc's setting at 400 psig. Simulations suggested that a lower setting (75 psig) could have relieved the first exothermic reaction, averting the second (p. 25).

5. Ethical Analysis of the T2 disaster: AIChE code of Ethics and the Tenets of Operation

In the author's class, ethical evaluations of T2's actions prior to and during the disaster concluded that the company neglected the first canon to "hold paramount the safety, health, and welfare of the public and protect the environment." Yet one could reach this conclusion with only a brief review of the disaster's background and history. A closer reading suggested that the third canon was also broken, in that T2 sought critical review of their work but did not heed it. The AIChE evaluation remains essential, yet because this exercise demands little scrutiny, learning opportunities are limited. As future plant employees, managers, and executives, students need to start questioning "why" and "how" ethics violations took place. A Tenet analysis demands a fuller understanding of the behaviours leading to events, so the "why" and the "how" can be investigated. One team analysing the T2 case found six Tenets broken, as shown in Table 2.

Table 2 Student Analysis of the T2 Laboratories Disaster (Schmid and Jagnanan, 2012; Zeglin, 2011)

Tenet Broken	T2's Specific Violation
1. Never operate equipment or tanks outside of design or environmental limits.	*The pressure relief valve on the reactor was set too high.*
2. Always move to a safe, controlled condition and seek assistance when a situation is not understood.	*The owner and process operator remained in control room rather than moving to safety.*
3. Always operate with safety devices armed.	*The cooling system lacked back-up water.*
4. Always follow all safe work practices/procedures and act to stop unsafe conditions and actions.	*The owners declared the process safe for operation without investigating risks and training others to recognize them*
8. Always address abnormal conditions and clarify/understand procedures before proceeding.	*Owners did not investigate causes of early "unexpected exothermic reactions"*
10. Always involve people with expertise and first-hand knowledge in decisions, improvements, and changes that affect procedures and equipment.	*Owners neglected the early consultant's advice for a Process Hazards analysis.*

The students first noted T2's disregard of the consultant's advice to run a Process Hazard Analysis, which could have predicted the dangers of high temperatures at metalation. This disregard broke Tenet 10, which insists on including experts in production decisions. The students next considered how the owners failed to investigate the unusual exothermic reactions during the first full-scale batches. Thus, they broke Tenet 8, which requires employees to investigate "abnormal conditions" and not proceed unless those conditions are understood. On the day of the disaster, one owner did not move himself or the process operator to safety, violating Tenet 2 and costing both of their lives. Allowing the reactor to run without an adequate emergency cooling system neglected Tenet 3, to "operate with safety devices armed." The students also regarded T2's lack of maintenance as an extension of this negligence. Tenet 4's demand to "follow safe procedures" could not be met at T2 because no one knew or sought what those procedures were. Finally, the contributing cause of the rupture disc being set too high at 400 psig violated Tenet 1: "never operate equipment...outside design limits" (Schmid and Jagnanan, 2012; Zeglin, 2011).

After this analysis of events, the students considered the implications of six Tenet violations. Recalling how CPChem related the number of Tenet violations to higher RIRs and greater costs, they recognized how a sequence of discrete risky decisions led to lives lost, injuries sustained, an environment damaged, a company destroyed, and a public endangered. The cost to T2 Laboratories, they realized, was "everything" (Schmid and Jagnanan, 2012).

One could question the specific Tenet analyses the students made--other students made different analyses of the T2 disaster--but such questions lead to productive discussion. Overall, the method of analysing incidents combining an ethics code with Tenets produced two benefits. Students appreciated the opportunity to practice an ongoing conversation about safety in one leading chemical company. More importantly, their work evinced an engagement with the human decisions and behaviours that can support or undermine an ethical work culture in multiple locales.

6. Conclusion

In Chemical Engineering, the new emphasis on process safety training for undergraduates underscores the importance of ethics education and offers opportunities to present different dimensions of case studies like that of T2 Laboratories. For undergraduates studying disasters like T2, however, a simple ethical analysis based on engineering ethics codes does not do justice to the history of poor decision-making and negligence that led to lost and broken lives, and harm to the public and environment. CPChem's Tenets of Operation offer one analytic method to isolate and assess the sequence of human decisions in process safety incidents. This paper shows one example of how undergraduates used the Tenets to examine the "why" and "how" of the process safety disaster at T2 Laboratories. Combining the AIChE code and the Tenets grounds the theoretical principles in engineering ethics with practical behaviours. This connection helps students and instructors alike realize the vital necessity of engineering ethics codes.

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New Teaching Strategies for Engineering Students – new challenges for the teachers

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Abstract: This paper presents the challenges for university teachers when new teaching strategies are implemented. Blended learning, flipped classroom, gamification as well as a combination of traditional and new pedagogical approaches are on the agenda in engineering educations. One of the challenges for the teachers is to adjust to the new way of teaching. We will use two cases; one longitudinal study and one experimental study to present and discuss a process of blended learning strategy in programming classes from a teacher's point of view: the strategy, the planning, the implementation and the learning outcome. The second case show that the blended learning model for programming classes works very well for another type of students. The results showed that blended learning using game elements is a successful way concerning the learning outcome, but is a challenge for the teachers involved. Finally, we will conclude with guidelines for other teachers, who want to use blended learning in their teaching activities.

Keywords: Engineering education, programming courses, blended learning, game activities, motivation.

1. Introduction

Currently blended learning is popular among educators because they view it as a necessary component of classroom teaching. There has been an increase of blended pedagogical methods, and research has revealed the various advantages of blended teaching, Ozak (2011), and blended learning is experienced as a valuable tool for student support and is suitable for different types of learners, Heinze and Procter (2004). Dziubi, Moskal and Hartman (2005) identified two principal advantages: learning engagement and the value of interaction among students and teachers. However it is also identified that the move from traditional teaching to blended learning has changed the role of the teachers and it has been a big challenge dealing with new dynamics, need of communication, leaving the traditional and well-known lecturing as well as turning the teaching in a more student centered way. Only few studies have focused on the new teacher roles when using new learning strategies, Hao and Lee (2016). During the last 8-9 years we have experimented with blended learning in programming courses at the Media Technology program, at Aalborg University. The teaching challenges were to develop a series of programming courses according to the objectives in the study regulation and which would be suitable for different types of students studying Media Technology. The Media Technology program attracted very artistic minded students and very technical minded students Reng and Kofoed (2012). One of the main questions was to find a pedagogical approach which could motivate all the different kind of students who were studying Media Technology to learn programming. During several pedagogical experiments a blended learning approach was found to be an acceptable pedagogical way to teach students programming.
In the following section, we present our experience and research in the blended learning approach.

2. New learning and teaching strategies

Flipped classroom, game based learning, blended learning as well as a combination of traditional and new pedagogical approaches are on the agenda in engineering educations with the aim to improve

the learning processes and maybe make it more efficient, Garrison and Kanuka (2004). A lot of discussions have been carried out as well as attempts to define the different methods.
The flipped classroom is an instruction method that has gained momentum during the last years due to technological advances allowing the online sharing of teaching material and learning activities. Lage et al. gave the following definition for this instruction model: "Inverting the classroom means that events that have traditionally taken place inside the classroom now take place outside the classroom and vice versa" Lage et al (2000). Bishop and Verleger found this definition very broad and noted that it implies that the flipped classroom only represents a re-ordering of in-class and out-of-classroom activities. Therefore, they defined the flipped classroom as "…an educational technique that consists of two parts: interactive group learning activities inside the classroom, and direct computer-based individual instruction outside the classroom", Bishop and Verleger (2013).
There are several different types of game based learning and motivation, ranging from the simple use of edutainment games, gamification, to purposive game development productions. The blended learning method has become popular with many educators, and is very often connected to online teaching and learning leading towards an approach combining conventional face-to-face sessions and online learning, which in this understanding is called hybrid or blended learning, Rogers (2001), but the Department for Education and Training (DET) provides another definition of blended learning. "Learning which combines online and face to face approaches" DET, (2003). DET has the virtue of simplicity but does not capture the potential richness as it is expressed in the definition from Procter, "Blended learning is the effective combination of different modes of delivery, models of teaching and styles of learning" Procter (2003:3). We find that this definition is more comprehensive, adding the dimensions of teaching and learning styles.
In this paper we use the theoretical frameworks and real life data to help our understanding of blended learning in practice and the way it fits the above definition, furthermore we will discuss the challenges for the involved teachers using blended learning.

3. Methods and theory

The "blended learning design" we use is guided by the Problem Based Learning (PBL) pedagogy, which Aalborg University applies since its establishment in 1974, Brage (2010). PBL is a student-centered pedagogical approach, in which learning begins with a problem to be solved. Students need to acquire new knowledge in order to solve the problem and therefore they learn both problem-solving skills and domain knowledge, Hansen et al. (2003). In PBL, the teacher's role differs from the traditional role as instructor. The teacher in PBL is a facilitator of the learning process, who is there to guide the students and to help when needed without instructing them what to do. All these characteristics of PBL are aligned with the aim and structure of blended learning approach and have affected our decision to integrate blended learning in our educational practice. PBL together with the study regulation has also guided decisions regarding the content of activities and the materials used as well as the setting for learning activities. The methods we have used are longitudinal case studies with interventions. During the last 8-9 years we have worked with programming courses at the Media Technology program. Each course is used as a case building on reflections and experiences from previous cases. Each case has been analyzed according to the theoretical foundation, and focus has been on the teaching strategy, the learning and the teacher's teaching experience and reflections using blended learning. During our research on the blended learning activities at the Media Technology Department, we proposed the use of Cowan's model of reflection for designing learning activities in blended learning classrooms that involve students' reflection loops, Cowan (2006). Cowan combined the analytical reflection from Kolb's experienced-based learning cycle: "experience-reflect-generalize-test", Kolb, (1984) with Schön's evaluative reflection for creating this model of reflection loops, Schön, (1983). Schön's reflection-for-action is the reflection that takes place prior to actions, while his reflection-in-action and the actual action take place at the same time. Kolb's reflection-on-action is more systematic than reflection-in-action and is a means to get from experience to conceptualization. Cowan's learning model is based on several reflection loops: reflection for – reflection in – reflection on, Cowan (2006) See Figure 1. We argued therefore that when learning activities are designed properly and the reflection process is facilitated by the teacher, the blended learning model with its different activities can be utilized to progress experienced-based learning.

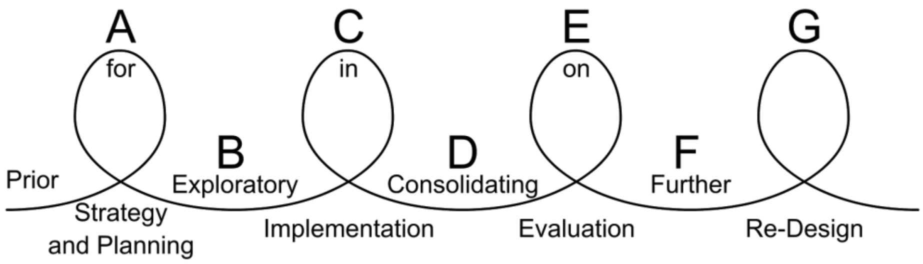

Figure 1: Cowan's learning model with reflection loops combined with the the learning design cycle: strategy, planning, implementation, evaluation, redesign during the blended learning process.

However, this model of reflection focuses only on a specific part of a learning process (how to design learning activities with reflections) and only on student learning in such strategy. Our experience has shown that teachers' participation in development or re-design of courses according to the blended learning approach is also a learning and reflection process for the educators Reng (2011). Cowan (2006) has extended his learning model with many smaller Kolbian reflection loops/coils between Schön's more general reflection loops. Therefore, in this paper we will discuss how Cowan's extended reflection model can be combined with a blended learning design methodology in order to support a holistic design and the reuse of blended learning methodology, while at the same time providing a framework for promoting and observing teacher reflection and development. See figure 2.

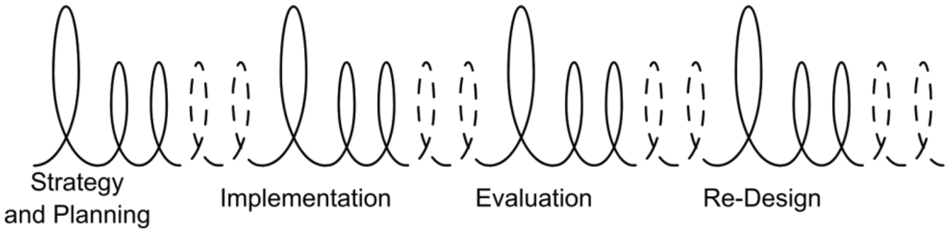

Figure 2: Cowan's extended learning model with reflection loops and smaller reflection coils. The reflection coils may vary in number according to the teacher's experience.

In the following chapter we will describe the cases focusing on the teachers' reflections that led to new ideas during the course or to re-design improvements.

4. Cases

In spring 2007 the coordinator of the Media Technology studies at Aalborg University, Copenhagen decided to change the programming course. The education had since its beginning, a few years earlier, struggled with the students' motivation and skills in the more technical topics (e.g. programming, image processing, computer graphics, artificial intelligence, etc.). Through one of the authors bi-yearly function as censor at the semester project exams it was clear that the courses need a new strategy, and he was offered to teach at the Media Technology with the aim of teaching several of the programming related courses. One characteristic of the engineering programs at Aalborg University is that each semester use 50% time on courses and 50% on a major project where students

work in teams.
Under the assumption that the only problem with the courses was that the previous teachers had been unfocused or inexperienced, the problems were expected to be easily solved with a well planned and executed series of lectures. None of the courses in the spring or fall semester of 2007 seemed to result in the desired skill levels for most of the students on any of the bachelor semesters. The students were simply not responding to the classical teaching methods normally used for these type of courses. After a series of meetings with the study coordinator, it was decided to make great alterations to both the courses and their relations to the large semester projects.

2008 Removing the lectures

Having experienced that the standard format, of two times 45 minutes of auditorium lectures followed by two times 45 minutes of group exercises, did not work for these students. They had understood so little from the 90 minutes of lectures that they were unable to even begin most of the exercises. Having to repeat the same parts of the day's lecture to almost every student quickly lead to the conclusion that the students needed to apply some of the basic concepts in order to understand more complex concepts from the same lecture.
The teaching of the courses was therefore moved away from the auditoriums into a flat classroom that would allow the teacher to both teach with projector and blackboard, and to walk around between the students and help them with their exercises. The format of the lectures began as 15-20 minutes of lecturing followed by 10-15 minutes of exercises for a total of three hours. As the year progressed the lecturing parts became shorter and the exercise parts longer. At this point the teacher was still going through the theory before given the students connected exercises. This method was applied to an Object Oriented Programming (OOP) course running on the students 4th semester in the spring, and an introductory programming course Procedural Programming (PP) running on the students 3rd semester (in the fall). It was clearly evident that this format was much better than the old standard 2x45 + 2x45 format. There was however still a very large group of students that seemed to have no interest in following the course, or completing the exercises.
The PP course was examined every January with an four hour written exam which was also used for the same course on the Media Technology education on the campus in Aalborg. The teacher in Aalborg would function as the censor for the Copenhagen exams, as the teacher in Copenhagen would function as the censor for the Aalborg exams. When this was first set up in 2007, the difference between Aalborg and Copenhagen was so great that we had to lower the passing requirements in Copenhagen by 20% to insure that ‘only’ about 50% of the students would fail the course. Even though we already in 2008 could use the same passing requirements as Aalborg, it was decided to raise the passing requirement with about 10% every year until every student passing the course were skilled enough to follow and pass the technical courses on the 4th, 5th, and 6th semester. More than 500 exam results from 2007 to 2011 are presented in Reng and Kofoed, (2012).

2009 Direct visual feedback for the artistic minded

After discussing with colleagues teaching the artistic classes, and several casual lunch meetings with older students, it became clear that one of the reasons that the teachers were having a hard time reaching most of the students were that most of them had no desire to learn or ever work with programming. Most of the students had joined the education for the artistic part of the curriculum in hope of learning the skills needed to work as a media artist. After many more casual ‘interviews’ with the student during the time the teachers were supervising them for their large semester project, it became clear that the students more or less would fit into one of three types: (1) The artistic minded student that had no interest in learning programming, and would try to find the minimum effort path to just pass the programming courses. (2) The media technologist student that was open to learn all courses. (3) The media engineer student that was mainly interested in the technical courses. See figure 3. Experiences from the media artist’s area gave reflections and ideas to visualize complex code as images, so the teacher decided to find more ways to visualize the examples used in the class. When offered to run both the Image Processing (IP) and PP course on the 3rd semester, it was decided to attempt to merge the courses and slowly to begin to use more image processing examples in the programing course and make sure the students would always implement a small program for every method they learned in image processing. The merge resulted in some improvements for the PP course, and a great improvement of the students' knowledge in image processing Reng (2011). The students this year seemed surprisingly unwilling to do homework in any course. A motivational boost was therefore needed.

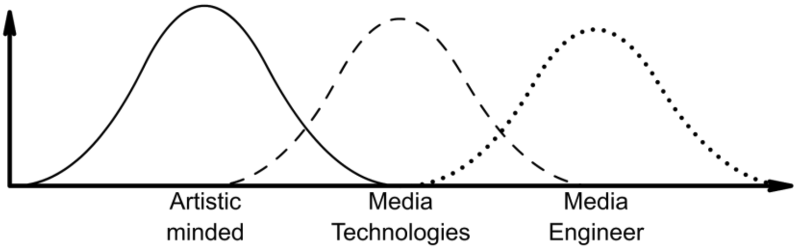

Figure 3: The three types of students on Media Technology

2010 Motivation & Exercises

Keeping everything that worked from earlier years, all lectures were now run as a kind of flipped classroom, with a list of books and video-lectures to watch at home, and all lecture time used to solve programming problems. It was in 2009 and 2010 that one of the most important rules was learned: "Always ask the students to attempt to solve an exercise in a topic before explaining it at the blackboard". By having the students realize that they do not know how to do something before explaining the theory and showing how to apply it, has a great effect on their motivation to follow the explanations on theory.

Seeing the effect of adjusting the course to motivate more students to follow the course and do the course exercises it was decided to implement three new methods to further improve the courses. In the beginning of the semester, one or more artistic minded master students were asked to show up and present their own examples of how it improves their skills as artists to have an understanding of programming, and the ability to write small scripts for graphical applications.

Another motivational initiative was the mandatory/forced hand – in of assignments. Every year there were a group of students that were working very little the first few weeks of each semester. This often resulted in some falling behind and eventually failing the course. So by adding a few mandatory assignments the first few weeks, this group was forced to work harder from the start.

The last initiative was inspired by some short meetings with the 're-exam' students each year. During the normal lectures, there were many of the weaker students that were very uncomfortable asking questions in a classroom with almost 100 students. Once the group was smaller, and only consisting of students that have all failed the ordinary exam, it was much easier to get the students to ask questions. Instead of waiting until all the weak students had already failed once, a small after school 'society' was created. And so the Dedicated Programmers Society (DPS) was born as an after school programming homework café, sometimes with almost 50 students.

Once again the passing requirements were raised by approximately 10% even though the exams were no longer shared between Aalborg and Copenhagen, due to a change in Aalborg.

2011 Give them a goal

When searching for powerful ways to motivate students it suddenly became clear that there are two parallel worlds attached to learning, motivation, and pedagogical methods. One is the academic world where each teacher is trying her best to optimize her courses to make the students learn a little more this year. The other world is that of top athletes and business people trying to optimize not the

courses but the ‘students’ ability to learn. Famous authors such as Napoleon Hill, Jim Roth, Brian Tracy, Stephen Covey, Anthony Robbins, etc. might hold one of the most important pieces to solve the learning puzzle. If students can learn to boost their intrinsic motivation and efficiency in everything they do. Then every course will automatically improve its outcome.
In order to test if these methods can affect the students, it was decided to use it in the courses which were run as in 2010. A small part of the first few lectures to introduce the students to Neuro Linguistic Programing (NLP) and the method of daily goal setting. Many students were confused to find this as part of the programming courses, and even though some claimed to have become better students, it was concluded that it should not be part of the programming courses. Instead a small course was added as a free study activity on the 1st semester. As a new initiative, a small two days recap workshop was held about a week before the exam. In hope that the students’ motivation to pass was at its peak, and that running through all the material again would help them see the relations between topics more clearly, and close a few gaps.

2012 Game Based Motivation

Having to give the OOP course to a new teacher, our focus was moved to the 6th semester Artificial Intelligence Programming (AIP) course in the spring. Unity (Unity3d.com) had released a free version of their popular game engine, and many students were keen to work with this in their bachelor semester projects. It was therefore decided to upgrade the AIP course, so it would take advantage of the students’ motivation and the power of a high end game engine. Most of the material, lectures and weekly assignments were designed as a framework for the Unity engine. This added a great motivational impact on the AIP course Reng (2012).
Based on the success from the 6th semester, it was decided to attempt to use the motivational powers of the Unity engine on parts of both the IP and PP courses. Especially the 3rd semester programming course (PP) was given several new game based programming challenges as part of the mandatory exercises. A small quiz game was developed in Unity to help the weakest students learn and remember the basic programming concepts. A few classical games were remade, using the Unity engine to present the graphics. By giving extra points for excellent sound or graphics, this helped motivate the artistic minded part of the students. It became evident that for most of the students, an opportunity to make their weekly assignments in the form of a game was motivating them to do projects several times the required size and complexity as they were used to.

2013 Game Development Based Motivation

A new teacher was taking over the IP course on the 3rd semester, breaking the merge between IP and PP. It was therefore decided to further build on last year’s success with game development and connected new challenges. The authors of this paper had, with another colleague, been asked to host the world's biggest game jam, Nordic Game Jam (NGJ). It was executed for the first time on Aalborg University Copenhagen in February 2013. This gave both students and teachers a more direct connection to the Danish, European, and global gaming industry. As a warmup to the NGJ several large companies offered to send professional speakers to present their software or hardware in the months prior to the NGJ. In order for the students to understand the experts from Unity, the authors of this paper decided to run a series of introductory Unity night lectures about a month before the invited experts. These lectures were held with open doors, allowing any new local game developer access to the university on equal terms with the students. To insure the students were highly motivated to follow the Unity night lectures, a mandatory mini game jam was set up for the students following the PP course. The feedback from the students was very positive.
As a result of the education undergoing accreditation, it was decided to serious inforce identical exams regarding programming courses across all three campuses: Esbjerg, Aalborg, and Copenhagen. The students in Copenhagen were now ahead in programming.

2014 Will the methods work outside the Media Technology education

After running free open-door Unity lectures for hundreds of local game developers and students from other universities, the authors of this paper was asked to give guest lectures, or run small courses or workshops on numerous local schools and universities in the Copenhagen area. Unable to do them all, a few were selected to test if the teaching methods developed for the PP, OOP, IP, and AIP course would work on a completely different kind of pupils or students. One case will be described to illustrate the flexibility and motivational power of using game based learning. The authors were asked to meet with a head of a school for challenged young boys and girls. It was boys and girls with several mental problems, and lack of abilities to function in social settings. The school attempts to bring these young people to a state where they might be able to get a simple job, and have a future. The head of school has noticed that several of the young people were interested in computer games. He was therefore asking if it would be possible to do some kind of game related activity to motivate them to at least show up at the school. When asking if it would be acceptable if we attempted to teach the pupils to develop professional computer games, instead of just entertain them, we were informed that the pupils could rarely stay focused for more than 15 minutes at a time, and often were missing for days or weeks. The first trail course was run as a once a week activity in the fall of 2014. Most of the pupils showed up on the days of the game course. Some became so interested about learning programing that they asked for permission to show up at the university and follow some lectures. Many became very passionated with developing 2D and 3D graphics both in and after class. So when the class ended in December 2014, the pupils made a Unity Christmas game for virtual reality. They made most of the graphics, sounds, music, and programming themselves. We quickly helped the school to find a good teacher, and the course is now running five days a week.

2015 Readjusting the methods to a different type of student

The PP was run for the last time in 2014, as a result of a new better study plan. Another programming course very similar to the PP course, but on another education very different than the Media Technology bachelor study needed help. This gave inspiration to evaluate which methods would be good for Media Technology students only, and also which might appeal to students without technical interests. The 2-year master's education in Service Systems Design (SSD) has a course; introduction to programming on the 1st semester which was a problem for all students. One of the goals for this course was that students would be able to build a simple app for tablets or smartphones after the course. None of the students were however looking for a future job which included any kind of programming. So the entire group of students had little or no interest in spending more time than needed on learning programming. It quickly became evident that the game and art challenges that could motivate the Media Technology students did not have much of a positive effect on the SSD students. We therefore used the last 15-20 minutes of the lectures to find an application that the students could see the benefit of having or being able to build. A talk with some of the other course teachers also revealed topics and applications from these courses that could be implemented in the programming course. The new type of exercises and challenges seemed to have some positive effects. The students remained skeptical towards the course, and began to fear the outcome of the exam. We decided to use the last lecture hours, to run a small three-day re-cap course a week before the exam. The three-day recap had, as expected, a great effect on the students and made many of them confident that they were ready for the exam. The exams were not graded by the authors of this paper. We were however happy to learn that not only did most students pass; many did so with very high grades.

We are now in the process of re-designing the course for the fall 2016.

5. Results

It is clear that each year the teachers during their teaching cycle have made a lot of reflections for using immediate new teaching ideas and for improving the redesign of the next year’s programming course. Furthermore, the pedagogical approach has influenced other courses. The Media Technology students are today at a much higher technical level than in 2007. Many of the changes made to the programming courses have been adopted by many of the other courses at the education. With a mix of flipped classroom, blended learning, game development, and artistic challenges we have successfully redesigned several of the programming courses with the aim of lifting the students' intrinsic motivation and their technical skills.

It is also important to mention that the challenges for the teachers have been rather big and a lot of resources have been used to plan, design, implement and redesign the courses during the process. The success goal has been reached and the different types of students have learned programming etc. The learning approaches - which started as blended learning approaches has turned out to be hybrid pedagogical approaches using blended learning -, flipped classroom - and gamification strategies.

Bringing this blended learning outside university, showed that the approach has a general positive effect for the different students'/pupils interests and motivation to learn and to learn more programming skills.

6. Conclusion

The pedagogical methods presented in this paper have brought success to the programming courses at Media Technology, and other programming related courses. Aiming to generalize the results to a list of guidelines for designing blended learning courses, each method must be evaluated in a different light connected to the specific topic.

Though it is relevant to structure the course within those different steps shown in Figure 1:

1. Strategy and planning, 2. Implementation and 3. Evaluation.

It is our strong belief that long blackboard lectures do not belong in modern programming courses. Instead, a focus on exercises and teacher-student defined challenges for problem to be solved is the better use of the teacher-student shared time. To generalize this to all blended learning courses, we would recommend that the course-designer first identifies what activities the pupils/students benefits most of having the course teacher or teaching assistant to present and which teaching/learning strategies should be used. In the case of programming we discovered that students lost their motivation when being stuck for longer periods with a buggy code or no ideas on how to start.

Many teachers often forget that students can lose motivation if working on frustrating problems they do not understand how to solve. It is therefore crucial to make each student understand how the course can benefit them in their future. Also, where possible, it is important to design exercises, challenges and quizzes so the student is intrinsic motivated to solve them.

Students really want instant or quick feedback upon solving a task or problem. If possible, use frameworks or applications that can instantly visualize if the job was correctly completed. Where this is not possible, we have great experience with peer-review or simply demonstrating one or more correct answers before moving on to the next problem. Also, do not explain all the theory before the students have tried and failed/succeeded in solving exercises within the concrete topic. Experience from trying to solve a problem will help them understand the exact part of the problem they are struggling to solve.

Finally, it is our experience that a blended learning teaching style can increase the quality of the short time the teacher has with the students, and is therefore highly recommended. The type of the course naturally restricts or enables different blended learning possibilities. Finding methods, topics, or challenges that triggers the specific group of students' intrinsic motivation can play a vital role in the success of a course.

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Teaching and Learning Hydrologic model using RORB to civil engineer students, opportunities and challenges

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Abstract: Flood is one of the most damaging natural disasters causing millions of dollars damage and loss of human lives across the world. Therefore, estimation of design peak discharge has a major role in engineering applications such as design of bridge, culvert, reservoir and spillway. To obtain design floods, a hydrological model such as RORB is used in Australia. This paper describes how a RORB model can be taught to a student having little knowledge in hydrology. It identifies the common difficulties a student and lecturer face in learning and teaching of the hydrological model RORB. It has been shown that both the student and lecturer need a well-thought strategy to teach/learn such a complex modeling technique.

Keywords: Engineering education, Hydrologic Model, Teaching /Learning opportunities and challenges

Design and Systems Thinking in Development Engineering: A Case Study of Liver Fluke Infection in Khon Kaen, Thailand

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Abstract:

Design thinking provides a rich human-centered toolkit for engineering design and problem solving that includes deep, needs-assessment, creative ideation, and iterative methods for feedback and rapid improvement. This paper focuses on the value of using systems thinking in reframing design thinking for complex problems in public health. Liver fluke infection in Khon Kaen, Thailand is used as a real health example where design/systems thinking helps to reframe problems with a more holistic view, and understand a system and a culture that creates and perpetuates liver fluke infections. In this example, well-intentioned educational interventions in the past have backfired due to lack of a design/systems framework. As an educational framework, design/systems thinking for complex systems applications, such as those in public health, can be used as a lens to analyze data and gain insights. Design/systems thinking has the potential to turn many health problems around and to find new ways to convince individuals to care for themselves and better self-design their lives. The paper concludes with implications and recommendations associated with engineering education in the nexus of public health in low income and developing regions.

Keywords: Design Thinking, Systems Thinking, Public Health, Development Engineering

1. Introduction

UC Berkeley has developed a new interdisciplinary Development Engineering or Design for Impact program (UC Berkeley, 2016) for students in economics, business, social sciences and engineering. Figure 1 illustrates the design thinking model (Beckman & Barry, 2007; Brown, 2008) used at UC Berkeley framed for development engineering to include development goals and constraints as well as business models for scaling (Levine et al., 2016). A design project would typically begin in the design research phase in the lower left quadrant and cycle clock-wise through the iterative design thinking process. Immersive user needs assessments (e.g., interviews and observations) would be analyzed to provide insights for framing the problem (upper left quadrant) and for developing imperatives and design principles (upper right quadrant) for concept development and prototyping (lower right quadrant). The cycle begins again when the concepts and prototypes are tested in the field with users, customers and stakeholders for rapid improvement (lower left quadrant again) and re-design. A large number of the development engineering problems identified for both research and as case applications in these courses are associated with public health challenges. An integrative systems approach to solving global health challenges in the nexus of medicine, public health and engineering call on new models of education (Garcia, Armstrong, & Zaman, 2014; Sandhu, Hey, Newman, & Agogino, 2005).

Public health efforts to change human behavior and make the world a better place often fall short of their goals. For example, although smoking is addictive and can lead to lung cancer and circulatory problems, many people still start and continue smoking. To contend with such issues, standards and regulations can help establish new norms. Regulations – including high taxation, limits on advertising, and creating smoke-free workplaces – have discouraged the habit to some extent. Yet, neither penalties nor incentives achieve what we are really after: a system and a culture that effectively discourages smoking.

Finding root causes for intervention failures in public health requires that designers include *systems thinking in framing problems and in developing insights from the data analyzed* (Dym, Agogino, Eris, Frey, & Leifer, 2005). Since problems may be inter-related, one needs to figure out how far to go in identifying the crucial actions needed to address the immediate problem of interest.

Using design/systems thinking as a lens, we explore the conditions that created and perpetuate the liver fluke infections endemic in Thailand in the first place. Originally framed as a problem of public health, most interventions focussed on developing numerous control strategies, such as stool examinations and treatment of infected people with an anti-parasitic drug and health education promoting eating of cooked fish. Alas, none of these strategies have done much to alleviate the problem (Jongsuksuntigul & Imsomboon, 2003). Between six and eight million people (Grundy-Warr et al., 2012; Jongsuksuntigul & Imsomboon, 2003; Sithithaworn & Haswell-Elkins, 2003) in Thailand are infected with *Opisthorchis viverrini* (a freshwater liver fluke). Some eventually develop cholangiocarcinoma (CCA), a cancer that initially involves the gallbladder and bile ducts and that spreads to the liver and beyond (Sripa et al., 2011).

Figure 1: Design Thinking in Development Engineering (Levine, Lesniewski, & Agogino, 2016)

2. Methods and Results for Educational Intervention

To understand the contexts (lower left quadrant in Fig. 1), one of the authors used a design thinking approach to first observe a Thai doctor and his students when they provided liver fluke infection information in places such as schools and local health centers. The first author later situated herself in the schools known to have relatively high child liver fluke infection rates. Through field observation in public places (e.g., markets, convenience stores, community science centers, and temples) and classroom observation, she interacted and talked with people, and saw firsthand how researchers/authorities and local villagers (e.g., students) worked together. Villagers were both male and female and ranged from age nine to approximately seventy. They included school-aged children, the middle-aged, and retired adults who either lived or worked in villages near Lawa Lake or Chi River. Some people were not highly literate, but all were fluent in the local Thai dialect.

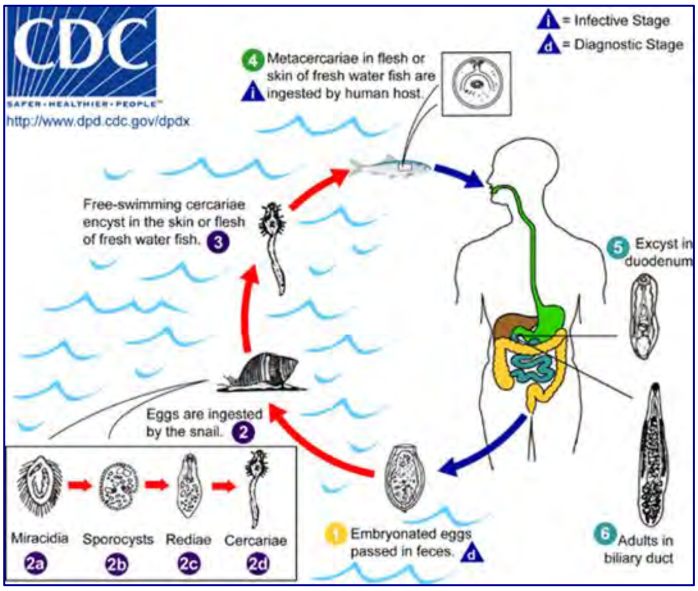
The paper uses design/systems thinking as an approach to frame and analyse the liver fluke infection problem in Thailand (upper left quadrant in Fig. 1). The approach suggests stepping back in order to "view from 10,000 meters," rather than a reductionist "divide and conquer" approach (Richmond & Peterson, 2001). Interrelationships among component pieces in a system are more important than separate details. Regarding the liver fluke case, we re-examine the following details and consider relations among each other: 1) Low-income populations consume undercooked fish; 2) the communities' efforts to control the infection have failed; and 3) Thailand has alarmingly high rates of liver fluke infection, and high levels of fluke-caused cancer. We often equate the community health intervention failures to the existence of undercooked-fish eaters, the high rates of the infection, or the high cancer rate. However, that might not be the case. According to the aforementioned interviews and observations, not everyone who ate the infected undercooked fish was infected by the flukes. Consequently, publicly available scientific knowledge about liver fluke might have little influence on the local villagers' fish eating behavior.

To confirm this, questionnaires were conducted to get an overview of *students*' knowledge about liver flukes and their familiarity with eating undercooked fish. Approximately 300 grade 4 to grade 9 students (N ~300) enrolled in two local schools filled out the questionnaires. Photographs and video-recordings of the environment were kept to document the situations. The subsequent interviews were later conducted with some selected students (N=36) to get a more in-depth understanding. Each interview lasted about 50 minutes. Based on the descriptive statistics obtained, firstly, there was no difference in knowledge between regular undercooked-fish eaters and non undercooked-fish eaters. In fact, all students seemed to have a good understanding of basic liver fluke infection information. Secondly, their knowledge was independent of past liver fluke infections. And lastly, the behavior of eating undercooked fish was independent of individual's past liver fluke infection.

The interview data were analysed and we found that even though students knew the basic science of the liver fluke infection, there existed some confusion, which might be caused by educational materials used during school health education programs for children (Fig. 2). The representations did not show how the liver fluke travels inside the human body. Some students thought that the disease gets into the body through fish and exits the body through feces (human *waste*); thus, eating under-cooked fish was no big deal. The picture also depicts one disease vector on a one-to-one ratio with other disease vectors. For instance, an egg ingested by a fish eventually generates one worm in the human. Despite this correct understanding, this could lead children to assume that one snail or one fish can only ingest or harbor one egg. However, in reality, many parasites can be buried under the fish muscle, and are passed through human feces. Lastly, the size of various stages of *O.viverrini* is somewhat misleading. Some may be led to believe that free-swimming cercariae can be seen with the naked eye, when its adult size is in the order of millimeters and the eggs are only in the order of micrometers (Kaewkes, 2003). Nonetheless, regarding issues of representation, it might not be possible to convey many concepts in one picture, and perhaps it is not wise to do so. That said, the picture may do justice to the travels of the disease vector, between various hosts, but the usage of it certainly requires more transparent and explicit instructions than the one currently used.

Thus, we devised a better representation of the liver fluke cycle (upper right quadrant), designed a short instructional intervention that goes with it (Fig. 2), and tested it with the same group of students (lower right quadrant in Fig. 1). The intervention took approximately 30 minutes. It was framed as a short lecture on the liver fluke infection. The hypothesis was that, although students had good general knowledge of the dangers of liver fluke, they did not understand the causality of and pathway of the disease over the liver fluke life cycle. In spite of this instruction and a better understanding of the causal pathway, however, students scored about the same in post-test questionnaires ($P < 0.05$). Clearly, there must be something more that influenced the local villagers' fish eating behavior besides the scientific knowledge of liver fluke infection.

Figure 2: Life Cycles of *O. viverrini*



System thinkers call this archetype "shifting the burden to the intervener" (Meadows, 2008). The solutions to problem come from outside interveners who can take a load off people's shoulders. They can say "it's not our problem to solve." However, this approach often entails people's dependency on researchers in the future. During the interviews, a quarter of the interviewed students mentioned the anti-parasitic drug that can cure the liver fluke infection. They seemed to have faith in modern medicine, and feel okay with the quick fix. A 7th grade girl, thought that if people infected with the liver fluke take medicine continuously, they will greatly reduce the amount of the parasites at a given time, even while continuing to regularly eat raw or undercooked fish. Even though the statement is false and even though the drug has side effects that increase people's chance of having CCA (Pinlaor et al., 2008), it reveals the dependent nature of some liver fluke infected people on a medical approach to the problem. The dependency occurs because the drug and health education programs do not change the way people think about health and well-being. The unrealistic expectation that modern medicine can provide a quick fix, may prevent people from critically analyzing their own reasoning processes and that lead them to continue to eat undercooked fish. We realized that in order to really understand the situation, we need to spend more time knowing the people in context (lower left quadrant again). Observations and interviews therefore were conducted over an additional three months.

For systems thinkers, real change is possible at the level of paradigm. Paradigms are the mind-sets out of which systems arise, and are "the sources of systems" (Meadows, 2008). Paradigms dictate rules of the game, our logic, our meanings, values, and societal norms. This is exactly the place where we should attack for change (Kuhn, 1996), because for change to occur, there must be a change in meaning. For this reason, we try to discover the underlying problems of the liver fluke infection through examining the worldviews of local villagers; the worldviews that represent people's "holistic and intricate picture of life, including its meaning and significance" (Tilburt, 2010). Perhaps, health has completely different meanings to them. To change their eating behavior so as to meet our definition of health may need a complete redesign of their thinking systems.

3. Reframing Using a Design/Systems Thinking Approach

The data were re-analysed with a focus on the people's thinking and their cognitive models associated with their eating of undercooked fish. The video transcripts and observation notes were recoded to look for the people's cultural and moral values, their beliefs, and "ways of life" (Douglas, 1966). Using systems thinking to analyse and reframe the data, we focused more on processes and relations, rather than on outcomes and controls. Combined with a literature review, we began to understand the facts, their relations, and the social processes that could perpetuate the undercooked fish eating behavior.

For the systems thinker, "[e]verything is…connected to everything else, and not neatly" (Meadows, 2008). In our win-lose cultures, helping people is about being nice and good to others. In a win-win culture, helping others is like helping ourselves. It comes with "the understanding that losers, …if they have no hope of winning, could get frustrated enough to destroy the playing field" (Meadows, 2008) that we are all in it. The most crucial issue here is to find the common ground among two seemingly opposites! There are no real angels or villains; no losers or winners. We need not take sides. We only need to pay more attention to "things that are working" underneath obvious controversies (Meadows, 1991).

Regarding the case of the liver fluke infection, there seems to be two groups of people here: undercooked-fish eaters and cooked-fish eaters. However, the two parties profoundly affect each other. People who eat undercooked fish can be bad role models for young children. Adults' eating undercooked fish can surely confuse young children who may think that they can eat undercooked meat only when they become grown-ups. The local villagers rarely thought that with poor sanitation systems, infected people are likely to pollute water sources (by passing liver fluke eggs through feces, and consequently perpetuate and proliferate the life cycles of *O.viverrini*). Both of the two groups of people have one thing in common: inability to connect their scientific knowledge with cultural patterns and norms. Perhaps, eating undercooked fish is perpetuated in the community through psychosocial mechanisms, which start at the psychological perceptions of what is socially acceptable (Christakis & Fowler, 2007; Marmot et al., 1991; Szreter, 2003). People familiar with seeing others eat undercooked fish unknowingly form abstract references to the normality of the practice.

When A affects B and B affects A, systems thinkers call this a *feedback loop*, which can either be a *reinforcing loop* or a *balancing loop*. Reinforcing loop: The more people doing nothing when seeing others eating undercooked fish, the more people unknowingly perceive eating undercooked fish as an acceptable behavior and/or as an individual matter. Given that many local villagers work as fishers and/or farmers, who have high debts and are away from their houses most of the day with no cooking ability, eating raw fish is a matter of survival—an affordable and traditional way of life, which allows them to preserve and affirm their own identity and culture. Eating undercooked fish is undoubtedly a culturally meaningful social activity. It created a lasting memory on a local villager:

> …During lunch out there in a farm, we would catch fish, chop it, put some salt and spices into it, and sometimes squeeze red ants on the tree—mostly mango trees, as the ants served as lime juice. Then, enjoy it together with other farmers….We didn't know about the liver fluke then, say 10 years ago, but I still had memories doing that[—seeing]… our ancestors ate it….

Health intervention programs serves as a weak balancing loop that tries to counter the strong reinforcing one that has long dominated local people's way of life.

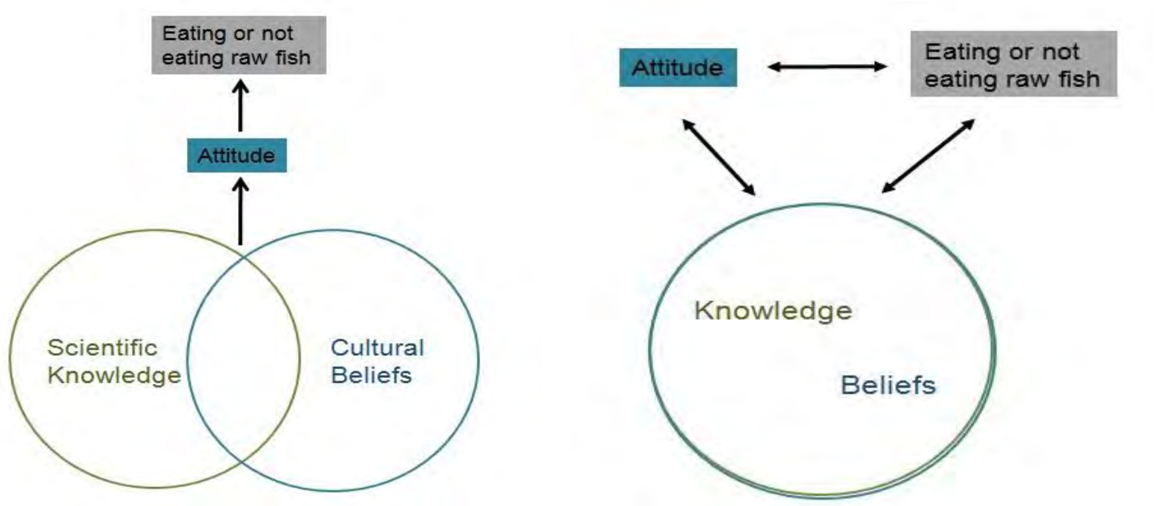
Systems thinkers encourage *continuum thinking* where there is no black or white, but only shades of grey. Regarding the case of liver fluke infection, "culture" should not be a dismissive term, juxtaposed against "reason." It is inappropriate to reassert science v. culture, knowledge v. belief, and science v. society. We might benefit from abandoning beliefs as products of culture and explanatory factors for irrational behavior, per Good's suggestion (Good, 1994). The difficulty in allocating definitely what causes liver fluke infection or cholangiocarcinoma validate the people's undercooked-fish eating behavior. During an interview, a middle-aged woman described her experiential knowledge that cannot be explained scientifically. She was perplexed with the fact that some undercooked fish eaters were not infected with the fluke. That is to say, we cannot take sides and judge whether the people's views are good or bad, right or wrong. Researchers' views *and* local people's views complete the story. Each is right about *one* different part.

World Bank economist Herman Daly, and Nobel-Prize laureate Herbert Simon called this phenomenon "invisible foot" and "bounded rationality," respectively. *Bounded rationality* means that "people make quite reasonable decisions based on the information they have. But they don't have perfect information, especially about more distant parts of the system" (Meadows, 2008). Systems thinking makes us aware that "the world is greater than our knowledge of it" (Berry, 2011), and that "[e]verything we think we know about the world is a model" (Meadows, 2008). The so-called irrational person (i.e., the undercooked fish eater) becomes a scientifically knowledgeable person with mere knowledge of human vulnerability factors (e.g., stress-induced sleep habits). Genetic factors may protect some undercooked fish eaters from the liver fluke infection. In other words, science and culture "are not intrinsically in conflict, and to assume that we must choose between them is to adopt an artificial or false dichotomy" (Christensen, 1987).

However, because we need to figure out how far to go in identifying the crucial actions needed to address the immediate problem of the liver fluke infection, the system boundary is drawn. We have put the behavior of eating undercooked fish within a theoretical framework, and draw a boundary between scientific knowledge and cultural beliefs for simplicity and for clarity (Meadows, 2008). This system allows us to holistically explain scientific and cultural factors affecting the high-risk behavior of eating undercooked fish in relation to each other, which may help us see the complementarities among the theories, and help us address the widespread liver fluke infection.

Our framework can be grouped into scientific knowledge and cultural beliefs (represented by the ovals in Fig. 3). Both individuals' scientific knowledge and cultural beliefs interact to form attitudes that lead to the behavior of eating fish (Fig. 3 on left). The two circles roughly indicate the two seemingly contradictory views (e.g., science and society, scientific rationalism and religion, health and spirituality) that we try to integrate. The boxes and circles represent concepts *conceptually*, while in reality, they are all intertwined (Fig. 3 on right). They simply serve as concepts to be explored in the research study. They are, in no way, predetermined themes to be reaffirmed in the fieldwork data.

Figure 3: Simplified Framework. (Left) Scientific knowledge and cultural beliefs interact to form attitudes that lead to the behavior of eating fish. (Right) The entanglement of scientific knowledge, cultural beliefs, attitudes, and the behavior of eating fish.



Using the aforementioned framework and sorting through both quantitative and qualitative data, we discover that both regular undercooked-fish eaters and non undercooked-fish eaters had a good understanding of the basic liver fluke information (e.g., the infection is caused by food we eat). Thus, providing people information on causes of illnesses clearly did not work as a health prevention strategy, and cannot promote behavioral change. Some local villagers believed in non-biomedical explanations about the causes that people perceived as beyond their control. They believed that the liver fluke infection is mainly caused by *kamma* (one's virtue) in past and present lives. Also, to these people, the "good life" involves happy family, and having food and money enough to survive. All this has nothing to do with having good physical health or living a long life.

The use of systems thinking in re-analysing and reframing data within a human-centered design or design thinking approach, allowed us to realize that there was a disconnect between scientific knowledge and cultural knowledge, which explained why so many interventions that focussed solely on scientific education have failed. Delving into the people's thinking and their thought system that might influence their eating of undercooked fish reaffirmed the need to redesign their thinking systems. We propose instruction that supports critical thinking that connects scientific and cultural knowledge. This could serve as a productive intervention. As pointed out by Vygotsky (1978), educators and researchers need to wisely adapt existing practices and teaching methods that promote deeper knowledge construction within a social context (Vygotsky, 1978). This provides the foundation for effective learning and behavior change in any field, but is particularly important in public health (Sandhu et al., 2005).

4. Conclusions and Implications for Engineering Education

Design/systems thinking helps us see the liver fluke infection problem in a more holistic view, and by extension, could help with other complex problems we face in the world today. Engineering education could play a significant role in promoting design/systems thinking at all levels of our educational systems with applications to wide range of global challenges. Design/ systems thinking supports critical thinking skills, transfer of learning, and self-reflective skill (metacognition), all of which provide the foundation for effective learning. Design/systems thinking helps learners tighten the links "between the various physical and social subsystems that make up our reality" – interdependence (Richmond, 1993), which is a basis for critical thinking skills. In systems terms, critical thinking skill is the ability to "see and deduce behavior patterns rather than focusing on, and seeking to predict, events" (Richmond, 1993). This deep understanding allows learners to transfer what they learn in one context to a different context, and know about what they know (and do not know), i.e., metacognition. Through design/systems thinking, students would learn to look at real-world problems from different angles. They would grow up to become productive citizens, whether it be researchers or general people of a community. They would think in a holistic way about problems they face in everyday life. This would help them understand themselves and be better able to analyse their own reasoning processes that lead them to do or not to do certain things, and better self-design their lives. We believe that "man's ability to participate intelligently in the evolution of his own system is dependent on his ability to perceive the whole" (Wallerstein, 2011), and design/systems thinking in engineering education can really change a prevailing ideology of hopelessness that is prevalent in low income and developing regions.

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Environmental Engineering for Civil Engineering Students: Challenges and Solutions

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Abstract: Started as public health engineering, environmental engineering discipline has grown into multiple branches (e g. environmental planning, sustainable development, air pollution, waste management/water and wastewater engineering). These multiple aspects are sometimes demanded by the accrediting bodies such as Institution of Engineers, Australia to be taught to civil engineering students. However, the time restrictions and necessity for civil engineering students to learn many related disciplines allow only a single unit to be taught and it makes it difficult to build on concepts previously taught. Percentage of students attending lectures has been steadily declining with recording of lectures and with increased flexibility offered to students. Therefore, the selection of contents and the engagement of students become a critical element to achieve a successful delivery. In this paper, the delivery methods are discussed. The unit content was divided into three different parts and each part had at least one of the following elements: laboratory practical, lectures, in-class quizzes, short videos and on-line quizzes and tutorials. The effectiveness of such an approach and learning are discussed.

Keywords: Civil engineering, environmental engineering, sustainable development, syllabus, students

1. Introduction

Next to military engineering, civil engineering is the oldest but a very vital engineering profession in the world (Cheah et al 2005). Because of its major focus on infrastructure & building and structures development, civil engineering is traditionally called as “public works” engineering. With the passage of time, civil engineering has spread its horizon by branching into various specializations such as construction engineering, structural engineering, geotechnical engineering, surveying, transportation engineering and water resources engineering (Cheah et al 2005).

Although every human activity in the world is being carried out to ensure betterment of humanity, the direct impact of civil engineering on human life is incomparable. Civil engineers steer the landscape of our planet from what was pristine to modernised architecture which shape the way the people live and the resources are utilised. Civil engineers’ role does not end just in freshly building the cities and towns and related infrastructure to sustain life, but also in rebuilding and/or quickly restoring them when they are hit by natural or manmade disaster.

Civil engineering activities alter every aspect of the environment (Table 1). For example, the produced dust from construction activities may pollute the air and storm water, bulk soil removal work from a construction site may affect the vegetation, wetlands and biodiversity. It will also have impact on social and cultural elements. The building material such as concrete needs exploitation of natural resources and energy. Earthwork may expose an acid sulphate soil and thus acidify natural waterways which provide aesthetic, social and/or economic value. The infrastructure in turn can affect the way energy is consumed in operation and the way people live and commute which eventually impact the environment. In short, civil engineers cannot work in isolation and need the knowledge of the environment more than any other engineer and should be able to integrate environment in their everyday professional life. Such realisation has led to integrating environmental engineering with civil engineering discipline in many universities (ex., University of NSW, University of Technology, Sydney).

Table 1 Branches of civil engineering that directly impact the environment (adapted from scope of civil engineering)

		Air	Soil													water														Energy
No	Civil Enginnering Specialisation	air pollutant	bulk soil removal	landscape change	Vegetation	wetlands	public park	erosion	habitat and bio-diversity	social and cultural strucure change	material use	bulk material handling	solid waste	landfills	natural hazards	water	river	catchment	groundwater resource	water trasport	water pollutant	sewer	sewer trasport	recycle water	storm water pollution	flood	drinage	coastal protection	oil rig	energy efficiency
1	Construction managemet	x	x	x	x	x			x	x															x					
2	Structural engineer										x																			x
3	Geotechnical engineering													x	x														x	
4	Surveying																													
5	Transportation engineering	x									x																			x
6	Highway engineering	x		x					x	x											x				x					
7	Hydraulic engineering																	x		x			x					x		
8	Earthworks engineering		x																											x
9	Sanitary engineering															x						x		x			x			
10	Wastewater engineering																					x		x						
11	Municipal or urban engineering						x					x	x																	
12	Engineering geology							x																		x				
13	Water resources engineering							x								x	x		x			x				x				

Environmental engineering traditionally has dealt with treatment or management of pollutant, waste, or water and was initially called public health engineering (Vesilind et al 2010). In 1854, Sir Edwin Chadwick reviewed the cholera outbreak in Thames River. About 10,000 people died of this outbreak. He proposed, "Health of people depended on sanitation, sanitation is an engineering issue requiring an improved water supply to houses with a proper arterial drainage system, a single authority should administer all sanitary matters in an area" and thus he is called the "modern father" of the disciplines of public health and public health engineering. Being called "public works" engineering, civil engineering has embraced this branch of engineering and civil engineers were traditionally trained in water treatment, supply and wastewater treatment and the management of water quality management in water bodies (Vesilind et al 2010).

The rapid industrialisation in 1970s resulted in vast negative consequences and needed specialised treatment of complex industrial wastes and other pollutants. Later, the treatment and management of wastes such as solid wastes arising from households and more complex and toxic industrial wastes and other pollutants were added to sanitary engineering which required a separate discipline and unique expertise. Hence, environmental engineering was born but at the same time the multidisciplinary nature of the environment and thus the need for scientists of multiple disciplines to solve environmental problems arose (Ashford 2004). This gave rise to environmental engineers specialising in air pollution, solid waste management, hazardous waste management and treatment, ecological engineering, and other scientists (such as microbiologists, chemists specialising environmental microbiology or chemistry) and more generally a discipline on environmental science was born (Ashford 2004). Although the speciality in environmental engineering has increased in breadth and depth, the importance of these aspects to a typical civil engineer has not reduced, for example in many water utilities civil engineers work as operators, managers, designers, modellers and planners. Civil engineers need to have the knowledge and awareness of source, pathway, receptor, impact and possible consequences and remediation of pollutants.

As the world population continued to increase and the intensity of activities increase (Davison et al 2010) and more people from developing world are beginning to participate in economic activities, the role of civil engineers will become even more important. It is widely accepted that activities, however, cannot continue at current rates and sustainable development has become a household name in every aspect of the human activity (Azapagic et al 2005; Chau 2007). With international movement towards sustainability, governments are not only committed to ensure sustainable development but also each of them vested the power to their environmental protection authorities (EPAs) to ensure that each economic activity will do minimum possible harm to environment as an independent regulator.

Civil engineering syllabus is very comprehensive and compact and do not have the flexibility to include anything more than one subject of environmental engineering, especially when universities move towards minimising the number of subjects. Within a subject, environmental engineering principles spanning across various spectrum (Table 1) should be taught. As per the requirement of the Institution of Engineers Australia, the unit was made a core unit and offered to second year students to ensure the students can practice sustainable practices while in the university and later in professional life. The following subsections list (Figure 1) and solve the challenges in achieving engaged learning outcomes which offers flexibility.

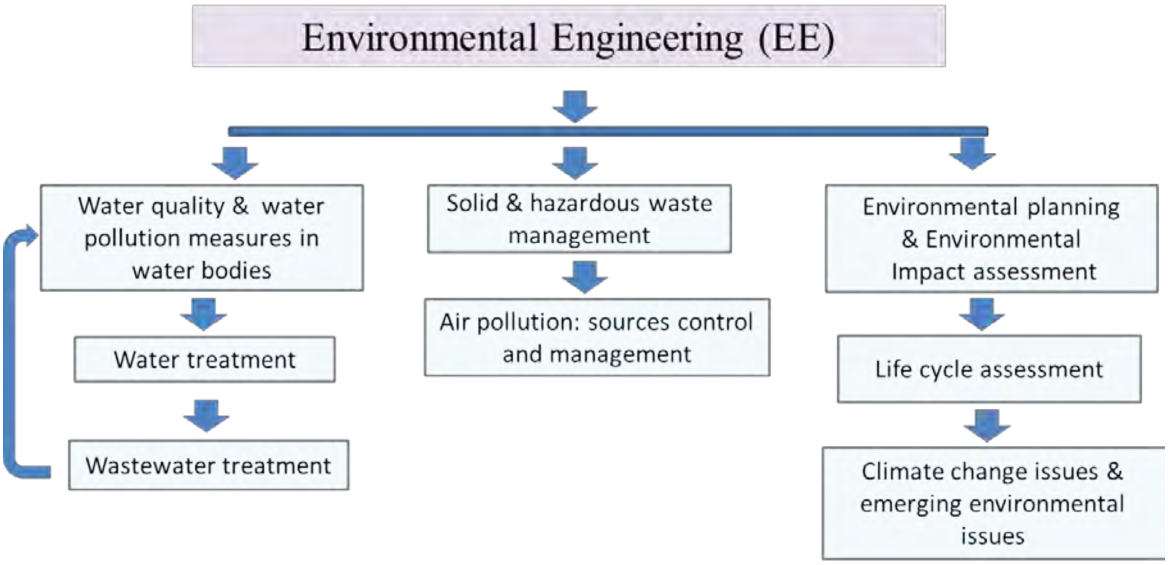

Figure 1: Major components of the Environmental Engineering

2. Method

2.1 Delivery method in 2013 to 2015 and challenges

While environmental engineering modules highly demand active participation of students on the learning process, complacency of the students, not mandatory requirement to attend lecture etc. hindered the student engagement and posed a big challenge (Graham et al 2001). Following sections explore the challenges.

Previous delivery (2013 to 2015) has the arrangement as set out in Figure 2. The subject contents had been delivered in three different ways: face to face lectures (a big group: 200 to 250 students in a class), tutorials (a small group: 20 - 25 students in each group) and laboratory demonstration (a small group: 15 to 20 students in each group). Far before the lectures, all the lecture notes prepared in Microsoft PowerPoint were made available to the students through University-wide flexible learning instrument vUWS. Moreover, the delivered lectures in the class were recorded (audio and video). This practice facilitated students to revisit the videos, if they missed the class or they could not understand the concept during the lectures.

As the lectures were delivered in a big group, to facilitate face to face discussion, tutorial classes were designed for a small group of students. Tutorial sessions were structured to ensure that the students are able to apply key concepts learnt in lectures to practical problems. It is expected that the students solve the tutorial problems themselves. Tutor is to assist the students in solving the problems and is not expected to provide a complete solution to the problems (Neville 1999). Practical classes were also designed to demonstrate how the theory taught in the class could be converted into the reality, but this was not assessed.

When the second year students started to take the unit in 2015, it was realised that the students' attendance was poor (70% in the first class to less than 10% in the last class) and the performance in the exam was poor with only 60% of the students passing the unit. Engagement with the lecture material revealed that students only viewed the lecture materials closer to the exams and only half of the students were viewing the online recorded lectures. This has made it difficult for the students to learn the content gradually.

In the previous years, three different assessing methods were used to determine the performance of the students. They were exams (mid-semester and final), attendance (students' attendance in the tutorial class) and group assignment (report and presentation). The weightage of group research project, mid semester and final exam were 20%, 25% and 55%, respectively. The laboratory demonstrations did not carry any marks. Having only three assessments, with only one of them during the semester, didn't help the students to obtain appropriate feedback.

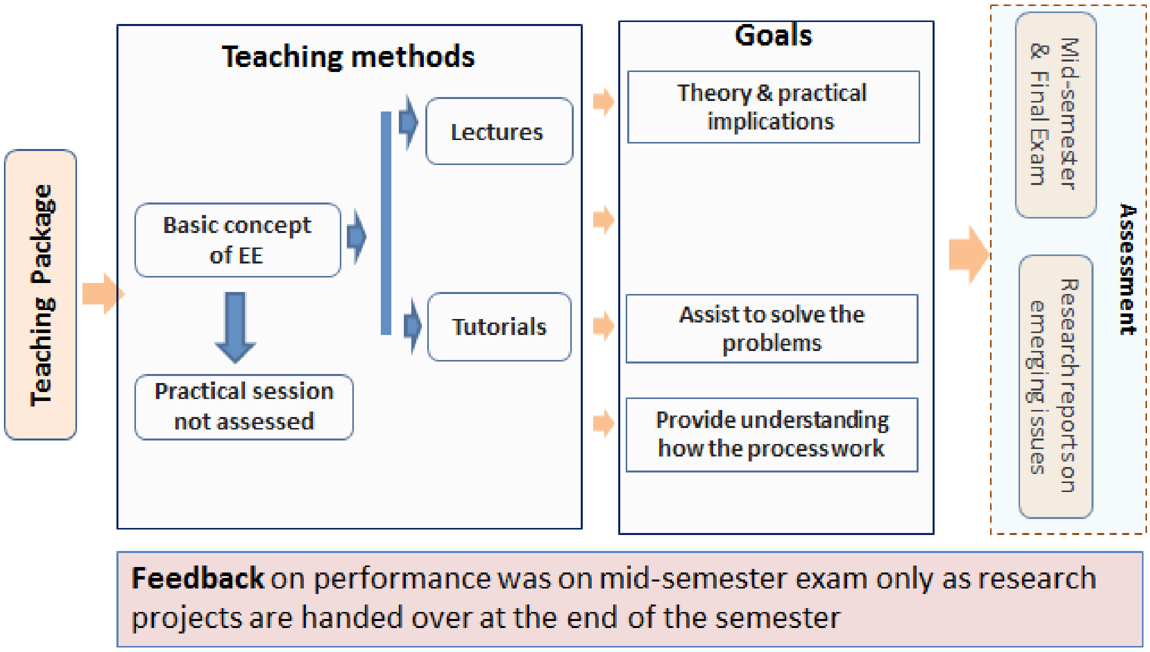

Figure 2: Teaching methods design between 2013 and 2015

2.2 Problem identification

Based on the students' performance, their feedbacks on the unit and self-realisation following problems were identified.

- Basic concept of the subject matter has been repeatedly asked by students
- Several questions from students towards the exam
- Poor attendance in the lecture and tutorial especially after the mid-semester exam
- Assignment part is heavy
- No marks were allocated for laboratory demonstrations
- Poor performance of the students in both mid-semester and final exams
- Not many assessments to improve students' performance

After the lecture, the majority of non-attending students found it hard to understand the basic concepts of the lecture contents. This could be due to several reasons such as absence in the lectures, not following the recorded lectures and the lecture materials were not enough. Several students did not engage during the lectures and tutorials. Many questions regarding the subject matters, especially fundamental concepts, were asked during the exam week through email. Numbers of students also increased for consultation during the exam week. This showed that most of the students read the lecture materials just before the exam. Increased students' engagement in the vUWS further confirmed such observation. As this subject contains a wide range of the topics (Davis and Cornwell 2008) needing different science background and starting to read just before the exam resulted in a poor performance of the majority of the students in mid-semester and the final exam. Moreover, after the mid-semester exam, students' attendance in the lecture drastically decreased which could be due to competing demands from other assignment from other subjects and/or the feeling that the recorded lectures could be viewed anytime. Since this subject involves theory, design calculation and practical application, face to face discussion is very essential (Graham et al 2001).

One of the assessing methods of this subject was a group assignment which was based on the literature review on various area of environmental engineering. As the students involved in the subject is largely of the second year and they had not developed a proper skill in literature survey and report writing, they had to spend the majority of their time in the assignment which could have impacted on the performance of the final exam.

As there were two major assessing methods (mid-semester exam and final exam) and an assignment of student's performance, students did not get many opportunities to improve their performance based on feedback.

2.3 Solution(s)

Based on the identified problems of previous years, an approach was developed which is detailed in Figure 3. In order to deliver the basic concept of the subject content, short videos (10 - 15 mins) were prepared along with online quizzes. Students were asked to view the videos and answer the related quizzes before they come to the lecture. Such exercise was expected to assist students to understand the basic concept before they come to the lectures and encourage them to engage with the lectures. Lecture materials and tutorials were also improved to bring in application of the concepts and further developments of the fundamental concepts. The delivery methods were same as the last year. However, students were encouraged to attend the lectures and note the solutions (the engineering approach the lecturer is taking) to these example problems and practical point of view utilised. Within lectures, various applications of the concepts and additional concepts were discussed.

The group assignment was replaced by the laboratory practical and field reports. The main objective of the field trip was to demonstrate how the process works in the real field. The field trip further allowed the student to simulate the theoretical and laboratory practical knowledge with the real application (McLoughlin 2004).

3. Results

The assessment method has been significantly changed compared to the last year. Mid-semester exam was replaced by three different in-class quizzes which are 30% weightage (10% each quiz). The quizzes forced students to be updated with the lecture materials on timely and also provided an opportunity to do the better in next quizzes if they made a mistake in the first one. The final exam weightage was 50%. Similar to the previous year, two practical sessions were designed. However, this year students were asked to write the report which covers the 10% of weightage. The field report also covers the marks (10%).

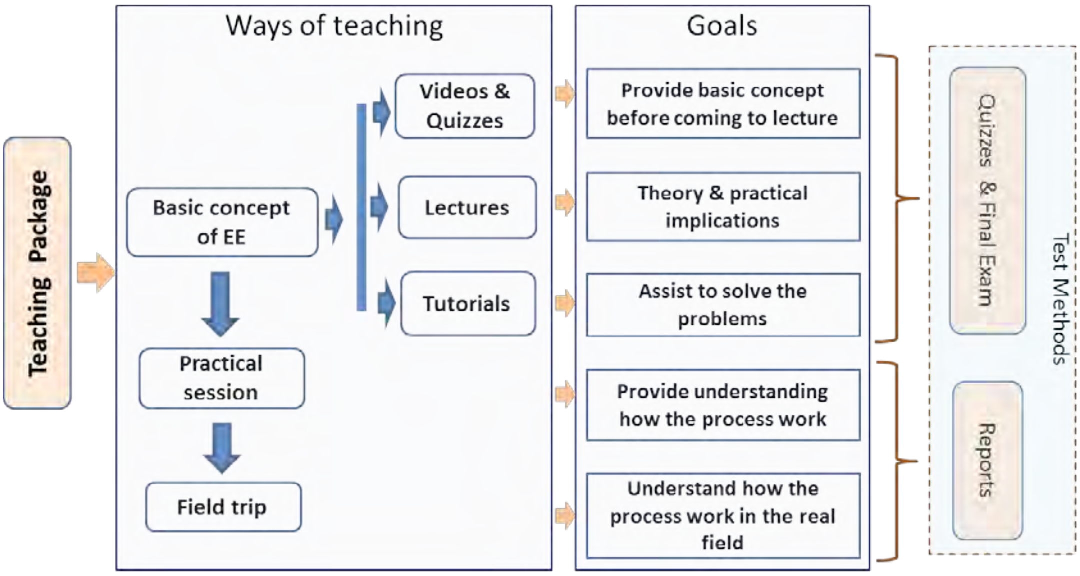

Figure 3: Details of teaching package and test methods of Environmental Engineering

4. Conclusions

The problem of the unit was identified through reflective practices and a solution was devised. The online availability of lecture materials made students to postpone learning until the end and to skip the lectures. Having only mid-semester exam and final exam added to this as they have to study only twice. This made the students not to do well in the unit. To continually engage short concept videos requiring completion of online quizzes in each week were released and in-class quizzes were conducted every four weeks to test the understanding of the concepts. Field trip and practical sessions were introduced to engage more with the contents. It needs evaluation of the performance, engagement, and feedback from the students to understand the effectiveness. However, from the verbal feedback of the students and the type of questions students asked, it appeared the design of the unit was better than last year.

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Teaching and learning of structural analysis using state-of-the-art commercial computer software: a case study

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Abstract:

Significant changes have been made in the field of structural analysis in last couple of decades due to availability of commercial structural analysis software and advancement of computer technology. The use and application of commercial structural analysis and design software in the industry by the engineers is also inevitable in near future. Therefore, the engineering students i.e. the future engineers need to have a good grasp of the correct use of commercial structural analysis software in order to correctly analyse and design the structures in the industry. Today's commercial structural analysis software are also integrated and linked to the design and drafting software, which makes the documentation easy for the industry. However, the incorrect modelling during analysis can be a significant problem as it affects the design and drafting output. This paper presents a case study where 3rd year Civil Engineering students at Curtin University were introduced two commercial structural analysis software in order to understand the behaviour of structures due to different restraint conditions, members end fixities, loadings, etc. and at the same time correctly model and analyse a complex 3-D structure and interpret the computer generated results and their accuracy. It was found that the introduction of commercial structural analysis software provided the students a first step in obtaining the proper *education*, not training, to use the best structural analysis method to solve real complex structures with a high degree of reliability.

Keywords: structural analysis, commercial software, teaching and learning.

1. Introduction

Teaching and learning of structural analysis to civil engineering students are traditionally based on different analysis methods for determinate and indeterminate structures. These involve lengthy calculations with lots of number crunching (Powell, G.H., 2008). Due to complexity of structures, the degree of indeterminacy increases and hence, the traditional methods of analysis using manual hand calculations become impractical in most occasions. Significant changes have been made in the present time in the field of structural analysis due to the availability of commercial structural analysis software and the advancement of computer technology. The availability of computers accelerated the use and application of commercial structural analysis and design software in the industry (Smith, 1984, Oreta, 2005, May and Johnson, 2008). Therefore, along with learning traditional structural analysis methods, the graduates also need to have a good grasp of correct use of the structural analysis software in order to correctly model the real structural condition in terms of boundary conditions, member connections, loads, etc.

An important skill required for the analysis of complex structures in the past was the ability to simplify the structural system into equivalent determinate system so that they can be analysed manually, with over estimating the internal forces of the structure. This means that the engineer needs to know number of methods which might be applicable to the analysis of a particular problem. Today, engineers are using commercial structural analysis software to analyse most of the problems. This can include complex geometry, multistorey frames, buckling, dynamics and second order analysis, etc. The problem for the structural design engineer has now changed from knowing different solution methods to how detailed an analysis is required. In the latter case, the engineer needs to know how correctly the structure can be modelled and how the errors associated with the modelling to applying the boundary conditions; member end fixities and loads can be minimized, as they affect the distribution of internal member forces (e.g. moment, shear force, etc.) in the structure. The use of structural analysis software also allows the engineer to understand the behaviour (forces and deflections) of whole structure due to different restraint conditions, member end fixities, loadings, etc.

The conventional analysis methods are tedious and time consuming and even some are limited to determinate structures. By using the commercial structural analysis software the indeterminate structures and even the complex 3-D model can be solved in a fraction of time, thanks to the user friendly graphical interfaces of current software. This not only allow the graduates to learn computer modelling techniques which they have to apply in practical life but also allow them to understand the behaviour of the structure and most importantly to check the accuracy of the computer generated results. However, the software are often termed as “black box” as graduates and engineers do not have any involvement in the calculations steps, but just providing geometry model with boundary conditions and loads. In correct choice of restraint conditions of the nodes of corresponding supports, member ends conditions corresponding to member joints, etc. can cause significant error in the computer model and can be catastrophic in many cases if engineers just accept the output from the software without any verification and check. This paper presents author’s experience in teaching structural analysis through adopting two commercial structural analysis software most widely used in Australian consulting companies in third year undergraduate structural analysis course at Curtin University, where the students used the software for better understanding of the behaviour of structures due to different restraint conditions, member end fixities, loadings, etc. The students also experienced correct modelling of boundary conditions, member end fixities and their effects on the behaviour of the structures and compared with that of approximate theoretical calculations to verify the software output.

2. The transition in structural analysis methods

The fundamental structural analysis methods such as, moment distribution, slope deflection, stiffness matrix methods, etc. are lengthy, time consuming and involve complex mathematical calculations. These methods sometimes obscure the better understanding of physical behaviour of complicated structures. Often simplification is made to the complex structural system in order to apply these analysis methods. Traditional structural analysis due to moving, dynamic and impact loads also involves lengthy procedure and complicated mathematical calculations. Although simplified methods exist but they yield conservative results. Often they differ from the actual results resulted in the over design of structures.

Due to availability of computers and commercial structural analysis and design software, the hand based calculation for structural analysis is seldom performed in the design office and completely shifted to the use of software. The growing use of computers in design practices has also increased the potential danger of computer abuse by novice graduates. Too much reliance on computer results without a proper understanding of the behaviour of the structural forms within the problem can lead to very expensive mistakes. The author believes that the utilisation of the power of computers to promote a better understanding of structural behaviour can be a useful tool in teaching structural analysis and behaviour to the students. The interactive use of computers can help achieve this goal. The author argues that the availability of computer software now allow a different approach to undergraduate teaching of structural engineering. This is also in line with the report published by the standing committee on structural safety (May and Johnson, 2008) which identifies more guidance on the use of computer software on understanding of structural behaviour, its modelling for computer analysis and on avoiding reliance on computer generated results.

3. The use of structural analysis software in the industry

Today, structural engineering programs run on ordinary PC's under Microsoft Windows, as well as other computers and operating systems. There exist a large number of commercially available programs such as, from Canada: SAFI (SAFI Quality Software Inc. 2002); SFrame (Softek Services Ltd. 2002); from the U.S.A.: GT Strudl (Georgia Tech Research Corporation 2002); Staad (Research Engineers Inc. 2002); SAP2000 (Computers and Structures Inc. 2002); RAM Structural System (RAM International 2002); Larsa (Larsa Inc. 2002); from Europe: Robot Millennium (RoboBAT 2002); from Australia Space Gass (Integrated technical software Ply Ltd, 2015), Multiframe (Formsys Ltd, 2015), Strand7 (Strand7 software development, 2015), etc. Most engineering and construction companies, and professional engineers use one computer program or another on a daily basis. Complex projects would have been almost impossible to realize without the use of modern computer programs.

Structural analysis software are improving rapidly and are becoming surprisingly powerful and user friendly. The following points are worth mentioning: graphical interfaces allow easy modelling of complex 3-D structures; data files containing material and cross-section properties allow quick definition of all elements in a model; loads and load combinations can be defined easily; advanced types of analysis, in addition to linear static analysis, can be done readily such as dynamic and seismic analyses, non linear large displacement as well as material non linear analyses; results, which include deflected shapes, support reactions, internal forces and stresses, modes of vibration, etc. can be displayed graphically on the computer screen or printed in full details.

4. Educational objectives

The educational objectives of the use of commercial software in structural analysis course are to improve and deepen the understanding on structural behaviour through correct modelling and analysis of structures and interpret and evaluate the results. The educational objectives of the *use of software in structural analysis* in this course are as follows:

1. *Modelling of structures in 2D and 3D*. Understand the fundamental basis of modelling structures using computer software.

2. *Modelling of boundary conditions of structure*. Know the physical behaviour and be able to model appropriate boundary conditions such as supports, end fixities of members, master-slave joints, etc. This also includes evaluating the effects of different boundary conditions on the structural behaviour in terms of member forces and deflection.

3. *Modelling of loads on the structure*. Be able to apply correct loadings on the structure considering the global and local axis.

4. *Analysis results interpretation and verification*. Be able to interpret and evaluate analysis results, including the importance of verification of member forces and deflection with approximate analysis.

5. *Software assumptions and limitations.* Be aware of the assumptions and limitations of software.

Side view

Front view

Fig. 1 Side view, front view and typical joints of a bus station in Perth City.

5. Assignment project design and assessment criteria

At the beginning, the students were taught about correct way of modelling and analysing a structure using commercial software followed by two tutorial classes where they practised and modelled two structures having different geometries, support conditions, member end fixities, loading conditions, etc. Later they were also given an assignment shown in Fig. 1 with the objectives of observing their understanding and efficiency on the use of commercial software to correctly model the structure including correct modelling of restraints and other boundary conditions, correct way of load applications, etc. In the assignment students were asked to model a 3D frame for a bus stop structure which consisted of curved roof over hanged from three columns through connecting two tension ties from top of the middle column as shown in Fig. 1. The connection details of typical joints of the bus stop structure are also shown in Fig. 1. Students checked the software output through simple manual check of approximate reaction values, deflected shape, shape of moment and shear force diagrams, etc. The overall objective was to let the students using the latest commercial software in the modelling of structures and better understanding of deformation behaviour, which is not possible using hand calculation.

The assignment was assessed based on marking criteria listed in Table 1 as each item is very important for correct modelling of the structure. Half of the total marks was allocated to decide on the correct nodal restraints and member end fixities of all nodes and members, respectively. Because incorrect choice of nodal restraint and end fixities of members will produce wrong internal forces in the members. 40% of total marks was also allocated to check the accuracy of the results and member forces e.g. bending moments, shear forces, deflection, reactions in the supports, etc. Because software is considered as “black box”, hence students should learn and apply methods to check and verify the software output.

Table 1 Marking scheme for the assignment

Items	Assessment criteria	Marks (%)
1	Correct frame model of the structure considering all primary structural members	5
2	Correct nodal restraint of all support nodes as well as other nodes connecting members	25
3	Correct members ends fixities to all members including tension only members connecting central column with curved beams	25
4	Correct application of various loads including wind loads in reverse direction to check the uplift of the frame	5
5	Correct deflected shape and SFD, BMD and AFD for each load cases	20
6	Check the accuracy of the model results by comparing the total applied loads vs reactions, shape of the deflected frame, negative moment in the base of the columns, zero moment in the tension only members, etc.	20

6. Typical modelling errors

During assessing assignments it was found that most of the students modelled the frame of the structure correctly by applying correct boundary conditions to the nodes and correct members ends fixities while a small number of students applied wrong boundary conditions at the top of the middle column, nodes joining the tension tie members and the curve beams, nodes joining curve beams and the columns. It is believed that they confused with connections shown at A, B and C in the structure shown in Fig. 1.

It was also found that these students did not verify the qualitative deflected shape of the structure due to applied load and accepted the all other outputs e.g. BMD, SFD and AFD. In this case they did not appreciate the visualisation capabilities of the software e.g. the deflected shape and did not thought that the structure will deflect horizontally and vertically down due to vertical loads on the roof or due to lateral wind loads. Some typical examples of wrong modelling of nidal restraints at nodes corresponding to joints at A, B and C (shown in Fig. 1) is shown in Fig. 2.

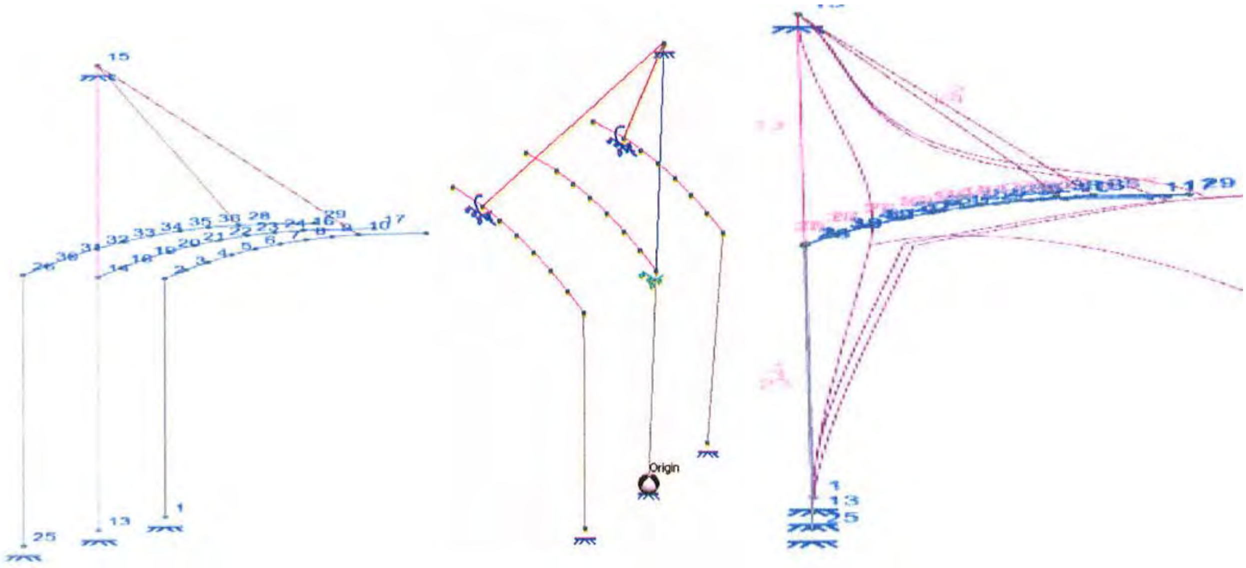

Fig. 2 Examples of incorrect modelling of supports and members joints and resulted wrong deflected shape

7. Conclusions

Based on authors experience in teaching structural analysis using commercial structural analysis software the following can be summarised:

There is always a possibility that students may apply wrong nodal restraints and fixities of members ends, which completely change the deformation of the structure under applied loads and hence the members internal forces and stresses. Software provided deflected shape of the structure should be checked with the expected one before accepting the software provided internal forces and stress. Even though students do mistake in the modelling the teaching structural analysis should include commercial structural analysis programs and present them in several courses in order to demonstrate concepts of structural analysis and complement classical teaching. Students introduced to state-of-the-art structural analysis computer programs will be better prepared for today’s challenges in the industry.

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Collaborative learning spaces: challenges and opportunities

(*invited paper*)

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Abstract:

Traditional method of learning and teaching (L&T) in universities that uses lectures and tutorials are proving to be less effective in engaging today's students. One of the strategies to improve student engagement and student learning is to replace the lectures and tutorials spaces with collaborative learning spaces (CLS). Students can use these spaces to collaborate and work on assigned tasks.

This paper presents the use of the CLS in a core civil engineering subject (unit) at Western Sydney University (WSU). L&T materials were developed to take advantage of the technology driven learning space. The experience of the facilitator in the development of the L&T material and use of the space are outlined. Student experiences are also discussed. The opportunities to improve student engagement and the challenges faced by both the facilitator and the students are highlighted.

Keywords: collaborative learning space, learning management system, project based learning

1. Background

Traditional method of learning and teaching (L&T) in universities makes use of lectures complemented by tutorial sessions. In this method, lectures are usually delivered in large theatres principally to disseminate information. Students in these sessions take on the role of a sponge, trying to digest the excessive information imparted on them. Tutorial sessions are then held in smaller groups where interactions with students, in the form of student-student and student-tutor occur. Effectiveness of this method is increasingly being questioned and is evidenced by continual decline in attendance patterns.

Tertiary education institutions have been trying to address this issue of declining student interest in lectures and tutorials by changing the physical environment where students are better engaged in learning (Wood, Warwick, & Cox, 2012). Termed as collaborative learning space (CLS), these spaces are designed with students' learning in mind where learning occurs through collaboration among the student peers (Beichner, 2014).

Western Sydney University (WSU) designed and constructed a prototype of collaborative learning space (CLS) supported by the state-of-the-art technologies. Students can attend sessions in this space to collaborate and work on the assigned tasks. Students also have the opportunity to 'zoom in' and actively participate in the sessions held in this CLS remotely. The zoom facility also enables specialist 'expert' guest lectures to be delivered from any corner of the world. Availability of this room presented a unique opportunity to trial a new L&T approach in a core civil engineering subject (unit) in Autumn 2016.

L&T materials were developed to take advantage of the technology driven learning space. The experience of the facilitator in the development of the L&T material and use of the space are presented. Student experiences are also highlighted. The challenges faced by both the facilitator and the students are outlined. Potential opportunities to improve student engagement using the CLS are listed.

2. Learning space design philosophy

The prototype room has been designed to facilitate teamwork. The room consists of ten moveable desks with a monitor at the end of each desk (see Fig. 1). Each desk can accommodate up to six students. The room is supported by a series of whiteboards spread throughout the room and a whiteboard camera. It also has a document camera tucked away on the lectern with a PC and a monitor. A number of software to display and share information (peer-to-peer and class sharing) and the Zoom facility are also provided.

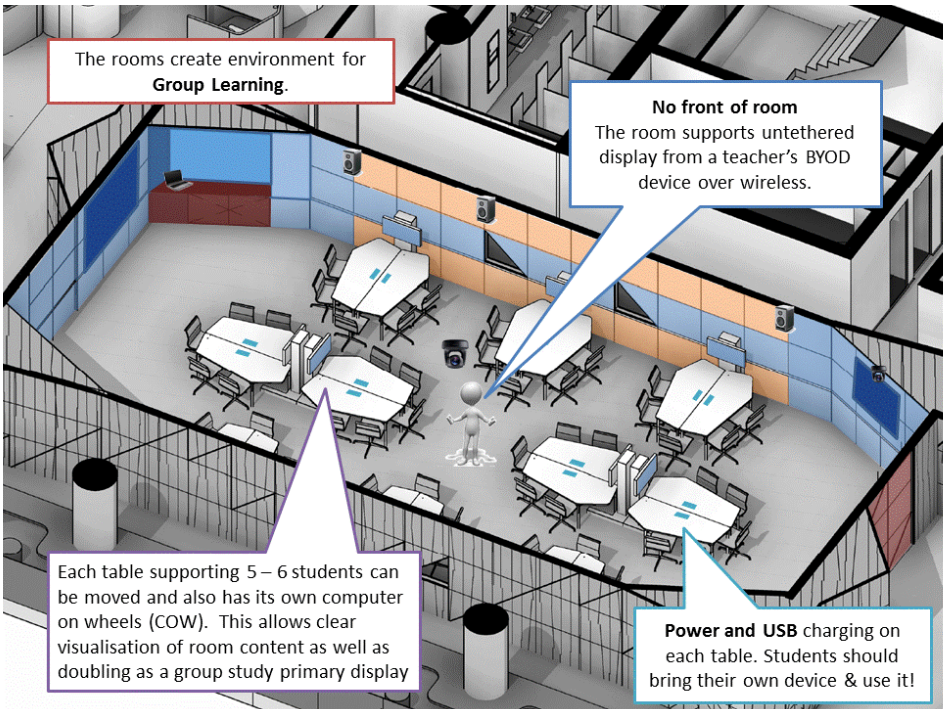

Figure 1. Collaborative learning space

3. Learning & Teaching (L&T) material design and delivery

In order to take advantage of the prototype CLS, the Learning & Teaching (L&T) materials were redesigned for a third year core Civil engineering subject, *Surface Water Hydrology*. While the learning outcomes did not change (to ensure that the Engineers Australia accreditation is not affected), the traditional L&T material were redesigned to fit the Project Based Learning (PBL) pedagogy using blended learning strategy of WSU. The delivery method was also changed from weekly lectures and tutorial sessions to evenly spaced full day workshop sessions. A total of five full day (8-hr long) workshop sessions replaced the weekly 2-hr lecture supplemented by weekly 2-hr tutorial sessions; minimising the variation in the total face-to-face contact hours.

3.1. Out-of-class preparation activities

Following the Flipped Classroom (FC) pedagogy, students were required to complete preparatory work before attending each workshop session, except for the introductory workshop session. Pre-recorded and sourced videos (durations ranging from three and half minutes to 66 minutes) were posted on vUWS, the learning management system (LMS) used at WSU. Power Point files were also posted regularly on vUWS, to disseminate information on workshops. This allowed for the workshop sessions to be devoted to meaningful discussions and question-answer sessions.

Students were required to complete a series of preparation tasks, including individual and group journals before attending subsequent workshop sessions. Entries made on individual journals, along with peer interactions during workshop sessions, were used to gauge individual student's engagement in the unit material - nominal mark for '*participation*' was awarded for this component. This approach (awarding nominal mark) allowed for implementation of compulsion for completion of out-of-class activities, implicitly forcing students to engage with the L&T material in a timely manner.

3.2. In-class interactive sessions

Students were required to attend a total of pre-scheduled five full day (8-hr long) workshop sessions during the semester. These sessions were used for in-class research, peer (student-student) interaction and student-facilitator interaction. The time in workshop sessions were used to clarify any confusions and doubts the students may have in solving the assigned real-world engineering project. In addition, these sessions were used to gauge student progress and their understanding of the L&T material and their ability to communicate with their peers. These sessions were effectively used to provide '*just-in-time*' supplementary information as identified during each session and as reflected in student journals.

4. Collaborative learning space

The layout of desks (see Fig. 1), known as CoWs (Computers on Wheels) facilitated peer-to-peer interaction during workshop sessions. The technology in the room allowed for the students to undertake live research and share their findings with their peers during the workshop sessions. This provided opportunities to share and learn from each other as identified by Gómez Puente, van Eijck, and Jochems (2013). This also encouraged the students to take ownership of their own learning (Bell, 2010) and achieve better learning outcomes (Shrestha, 2016). It is noted that other researchers have argued that such approach results in improved student engagement and learning (Kim, Kim, Khera, & Getman, 2014; Mason, Shuman, & Cook, 2013).

5. Implementation and Experience

The redesigned unit, *Surface Water Hydrology*, was delivered in the prototype CLS at the Penrith campus of WSU during Autumn 2016. The unit is a third year core Civil engineering unit that focuses not only on technical learning outcomes but also on a number of soft skills required for Stage 1 Competency Standards for a professional engineer (Engineers-Australia, 2013). The soft skills this unit focussed on were *effective teamwork skills*, *oral communication skills* and *written communication skills*. Additional learning outcomes included *technical skills in the specified area* (engineering hydrology), *problem solving skills* and *independent research skills*.

A total of 95 students were enrolled in this unit in Autumn 2016. The students were distributed in 25 teams; number of team members ranged between three and five. The students themselves were responsible for picking team members, following the presentation of the *Belbin* model (Fisher, Hunter, & Macrosson, 1998) during the introductory workshop session and after completion of the self-assessment exercise during the session.

5.1. Student experience

Both the CLS and the hybrid L&T approach (PBL supplemented by FC) were new to the student cohort and the facilitating team. To ensure that the students were progressing well during the semester, they were encouraged to e-mail regular feedback to the teaching team. They were also encouraged to post their personal reflections on their personal journals on a regular basis. These were in addition to the end-of-semester student feedbacks on the unit (design, delivery and space) as well as teaching effectiveness. One of the e-mails a student sent at the beginning of the semester stated,

> *"The opportunity to be the first class to use the Prototype Room is one that seems interesting, along with the project to be completed in a "real world" type environment is one that I am very much looking forward to."*

As per the room design and the technology available in the room, another student wrote,

> *"I liked how the room was designed to satisfy the purpose of team working as the tables were set up nicely and the computer on the tables were really fun as it had the new tools where you can see what the people share with you."*

The discussions that were taking place between peers and the questions being asked of the facilitators suggested that the L&T approach adopted in this unit was working well. The assessment format that required team members to make presentation in-front-of their peers was insightful and was found to be very helpful in building confidence. This also required the students to work effectively in team and put additional efforts to solve the problem on hand, as one student put eloquently, "*no one likes to look stupid in-front-of your classmates*"; the fear that their colleagues will judge them harshly encouraged them to work harder to achieve respectable outcome for their project.

As with any new technology, there were regular hiccups in use of the technology in the CLS. The main problem was related to Wi-Fi connectivity in the room; it kept on dropping out, causing frustrations, throughout the semester. In addition, there were issues with the *Solstice* software used to display and share contents. As with Wi-Fi connectivity or lack thereof, problems with the display software was a major cause of discomfort and frustration; and this lasted throughout the semester.

5.2. Facilitator experience

Power Point slides and video materials were developed, sourced and collated by the unit coordinator (who was also the lead facilitator) and posted on vUWS. The workshop sessions were facilitated by two facilitators and the journals were assessed by these facilitators. Both the lead facilitator and the associate facilitator have practical engineering experience, in addition to being experienced tertiary educators. However, neither of them had experience of the hybrid model nor did they have experience in teaching in the technology enhanced CLS. In other words, both the facilitators and the learners were new to this system of L&T.

The facilitators met after each workshop session to discuss their experiences and how they felt the students were engaging in the unit material. These discussions along with the reflections described in student journals identified the improvements needed as the semester progressed. Both the facilitators felt that the students were engaged and were involved in deep learning activities. They also observed that the students were able to find innovative solutions to the real-world engineering problem they were trying to solve. They also felt that the CLS is contributing to better learning outcomes for the students, mainly from successful development of soft professional skills (teamwork and communication skills identified earlier).

6. Results, Discussions and Conclusions

Learning outcomes were gauged from three different assessment tasks – student journals, in-class (in-semester and end-of-semester) oral presentations and a technical report. The student journals and oral presentations were individually marked whereas the technical report was assigned group mark, considering peer assessment to gauge individual student contributions. The results are presented in the companion paper (Jones & Shrestha, 2016). It was observed that the CLS contributed to student engagement and the results indicated better student learning outcomes (see companion paper by Jones and Shrestha (2016)). The students enjoyed the opportunity the CLS provided to collaborate and share their findings with their peers. The room was also found to be helpful in providing additional avenues to find answers to the questions the students were struggling during their journey.

The students appreciated the opportunities the CLS provided in terms of collaboration and the ability to engage with their peers and the teaching team. However, the constant issues with Wi-Fi connectivity and the display software Solstice were major headaches. Both the students and the teaching team felt that the L&T style provided real-world engineering experience and the learning space (CLS) assisted greatly in ensuring that the students were able to achieve the unit learning outcomes.

7. Acknowledgements

The author acknowledges the feedback of the students enrolled in Surface Water Hydrology in Autumn 2016. The author also acknowledges the contribution made by the associate facilitator during the workshop sessions.

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Curriculum Mapping Tool and Engineering Curricula Development

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Abstract:

Engineers Australia (EA) has a set of requirements for accrediting engineering programs. Known as Stage 1 Competency Standards, the 16 elements of competencies ensure that engineering graduates have the necessary technical skills as well as soft skills required to join the workforce and contribute effectively to the society (Engineers-Australia, 2013). In addition to EA requirements, each tertiary institution usually has its own quality assurance criteria. At the Western Sydney University (WSU), as a part of the quality control mechanism, three committees at different levels scrutinise every proposed program. Once the proposed program passes through the scrutiny of these committees, the Academic Senate approves the program. The program is then delivered by the School proposing the curriculum.

The suite of Bachelor of Engineering programs developed by the School of Computing, Engineering and Mathematics (SCEM) went through all of the abovementioned processes. A curriculum mapping tool (CMT) was developed and implemented to guarantee that all unit (subject) and course learning outcomes were achieved by each suite of the proposed programs.

This paper presents the use of the CMT in successful mapping of the BEng suite of programs at WSU. The usefulness of the tool is highlighted.

Keywords: curriculum mapping tool, accreditation, Australian qualifications framework

1. Background

Curriculum development for a tertiary level course is an exhaustive process that involves a large number of constituents. Some of these groups are within a tertiary institution whereas others are outside the institution. The whole process has one central purpose – to ensure quality of the curriculum developed for implementation.

The quality assurance system within a tertiary institution, usually, has multiple layers. The multilayer quality assurance system within the Western Sydney University (WSU) ensures that every approved program has been designed to satisfy the Australian Qualifications Framework (AQF) Council's requirements. At WSU, School Academic Committee (SAC) is the School level committee that ensures that the proposed program fits within the School's vision. Once endorsed by the SAC, the proposal is scrutinised by the Curriculum Quality Committee (CQC). The endorsed proposal then goes to the Academic Planning and Course Approval Committee (APCAC), which is a sub-committee of the Academic Senate. The Senate approves the APCAC endorsed curriculum for implementation by the School.

The suite of Bachelor of Engineering programs developed by the School of Computing, Engineering and Mathematics (SCEM) went through all of the abovementioned processes. In addition, the programs also had to satisfy all 16 elements of the Engineers Australia (EA) Stage 1 Competency Standards. A curriculum mapping tool (CMT) was developed and implemented to guarantee all unit (subject) and course learning outcomes were achieved by each suite of proposed programs. The mapping tool was also used to check whether the programs met the EA Stage 1 Competency Standards.

This paper presents the use of the CMT in successful mapping of the BEng suite of programs at WSU. The usefulness of the tool is highlighted.

2. Learning Outcomes

2.1. Course Learning Outcomes

As a part of program redevelopment to meet EA Stage 1 Competency Standards and AQF requirements, all undergraduate engineering programs at WSU were redesigned. The first step was to seek input from EA to determine the process of meeting the EA requirements. A workshop facilitated by an experienced EA Accreditation Panel member, with extensive experience in managing accreditation visits, was organised for this purpose. This workshop was followed by a second workshop, facilitated by the Curriculum Advisor and the Course Quality Officer under the leadership of the Director of Academic Programs, to develop the course learning outcomes (CLOs) that meet the EA requirements while fulfilling the requirements of the university graduate attributes. The workshop resulted in WSU engineering's overall objective of 'producing industry ready graduates with hands on experience.' A total of eight CLOs specific to WSU engineering graduates were developed. The eight CLOs, 16 elements of EA Stage 1 Competencies and nine WSU graduate attributes and their links are presented in Table 1. The External Advisory Committee (EAC) was involved throughout the process.

2.2. Unit Learning Outcomes

Each of the five key programs (Civil engineering, Construction engineering, Electrical engineering, Mechanical engineering and Robotic & Mechatronic engineering) offered at WSU has 32 x 10CP units. A full time student enrols in 4 x 10CP unit each semester and completes the program in four years. A graduate achieves the CLOs through achievement of unit learning outcomes (ULOs) of individual units. The units themselves have been designed to provide the scaffold needed to achieve the eight CLOs.

Table 1 – EA Stage 1 Competencies, BEng Course Learning Outcomes and Western Sydney Graduate Attributes

EA Stage 1 Competencies	Engineering Course Learning Outcomes	Western Sydney Graduate Attributes
1. Knowledge and Skills Base (PE1) PE 1.1 Comprehensive, theory based understanding of the underpinning natural and physical sciences and the engineering fundamentals applicable to the engineering discipline PE 1.2 Conceptual understanding of the, mathematics, numerical analysis, statistics, and computer and information sciences which underpin the engineering discipline PE 1.3 In-depth understanding of specialist bodies of knowledge within the engineering discipline PE 1.4 Discernment of knowledge development and research directions within the engineering discipline PE 1.5 Knowledge of contextual factors impacting the engineering discipline PE 1.6 Understanding of the scope, principles, norms, accountabilities and bounds of contemporary engineering practice in the specific discipline **2. Engineering Application Ability (PE2)** PE 2.1 Application of established engineering methods to complex engineering problem solving PE 2.2 Fluent application of engineering techniques, tools and resources PE 2.3 Application of systematic engineering synthesis and design processes PE 2.4 Application of systematic approaches to the conduct and management of engineering project **3. Professional and Personal Attributes (PE3)** PE 3.1 Ethical conduct and professional accountability PE 3.2 Effective oral and written communication in professional and lay domains PE 3.3 Creative, innovative and pro-active demeanour PE 3.4 Professional use and management of information PE 3.5 Orderly management of self, and professional conduct PE 3.6 Effective team membership and team leadership	WSU Engineering will produce industry ready graduates with hands on experience who will have: 1. a comprehensive and coherent body of knowledge of scientific principles applicable to solve engineering problems (EA Stage 1 Competency PE1) 2. an ability to fluently use systems approach to identify and solve engineering problems in specialised domains (PE1 & PE2) 3. the expertise to employ research skills to find practical solutions to engineering problems (PE1 & PE2) 4. an enthusiasm to actively seek and adopt sustainable solutions to local and global problems (PE1 – PE3) 5. an ability to engage in multi-disciplinary teams in a professional and ethical manner (PE3) 6. strong oral and written communication skills to effectively convey knowledge and ideas in a variety of modes (PE3) 7. sound leadership and project management skills (PE 3) 8. the skills to recognize progress in their field and the commitment to pursue continuous professional development (PE1 – PE3)	A WSU graduate will have the following attributes. 1. **Communication Skills** - Communicates effectively through reading, listening, speaking and writing in diverse context. 2. **Numeracy Competency** - Applies appropriate numerical skills to understand, interpret and solve problems. 3. **Social & Teamwork Skills** - Is a self reliant learner who works effectively in groups and teams. 4. **Information Literacy** - Accesses, evaluates and uses relevant information to solve problems and to continue learning. 5. **IT Literacy** - Applies communication and other technologies effectively in personal and professional learning. 6. **Indigenous Knowledge** - Demonstrates knowledge of indigenous Australia through cultural competency and professional capacity. 7. **Connected Knowledge** - Demonstrates comprehensive, coherent and connected knowledge. 8. **Critical Problem Solving** - Applies knowledge through intellectual inquiry in professional or applied contexts. 9. **Civic Values** - Brings knowledge to life through responsible engagement and appreciation of diversity in and evolving world.

3. Program Structure

The five key programs at WSU have been designed with the following broad principles.

Formative year – the program has the common first-year structure. Students are exposed to three different types of units during first year of study. These include,

i. *Preparatory Units* – Mathematics and Science form parts of the preparatory units. Students who enter without adequate Mathematics background will be streamed into a lower level Mathematics unit that will prepare students to successfully complete the higher level mathematics units later during their engineering study.
ii. *Academic Literacy and Information Literacy Unit* – One unit has been specifically designed to assist students' transition from High School to University. The unit incorporates academic and information literacy components. This unit also acts as an introduction to Engineering as a satisfying and rewarding profession. Students undertake guided projects in interested areas and work in teams, presenting their findings in technical report and class presentation formats.
iii. *Exposure to Engineering disciplines* – Three units, covering the five key programs, provide introduction to various engineering disciplines. These units act as foundation units in various engineering disciplines.

Junior year – Units in this year form the building blocks in each key program. All eight units, 10 CP each, are discipline specific units and provide basic engineering principles in the chosen area. A significant proportion of units in this year are analysis units, preparing students to successfully engage in design units that are offered during senior years. The introductory units in the junior year also act as foundations for specialised units students undertake during their senior years.

Senior years – Students are exposed to design and advanced units (for specialisation) during the third and the fourth years of their study. These are also the years when students undertake group project work (spread across two years of study, spanning two semesters) and thesis work. Students are exposed to four specialist units that enable them to graduate with a sub-major. A total of ten sub-majors, across the five key programs, were identified.

4. Curriculum Mapping Tool (CMT)

The CLOs were developed, in consultation with the EAC, to meet industry needs while satisfying EA Stage 1 Competencies and WSU graduate attributes. These CLOs were achieved through a considered mix of aligned units that have specific ULOs. These units were designed to introduce specific competencies in the junior year, which are subsequently developed and assured in senior years to give confidence that the graduates possess desirable knowledge and skills. The graduates achieve competencies in academic literacy, information technology, research skills and engineering practice through a series of scaffold units. The EA Stage 1 Competencies and the levels of assurances are achieved from each unit, for each key program. This is a highly convoluted and complex task and was achieved through the use of the curriculum mapping tool (CMT) where learning outcomes of each unit were mapped against the CLOs for the key program. A typical result of the CMT and its interpretation are presented in Fig 1.

Fig. 1. Interpretation of mapping tables resulting from the Curriculum Mapping Tool

5. Results and Discussions

The CMT proved to be an invaluable tool in mapping the ULOs against CLOs for each of the five key programs at WSU. The mapping of levels of attainments proved to be highly useful in ensuring that each key program will produce the graduates with desirable attributes and competencies. An analysis on content emphasis in the undergraduate engineering key programs resulted in the distribution of contents related to each CLOs as shown in Fig. 2. It is evident that the content distribution on the eight CLOs are meaningful. When the proportion of CLOs were mapped against ULOs for the core units in the undergraduate engineering program at WSU, the results shown on Table 2 were observed. Once again, these results show that the programs designed are reasonable and fulfil all requirements.

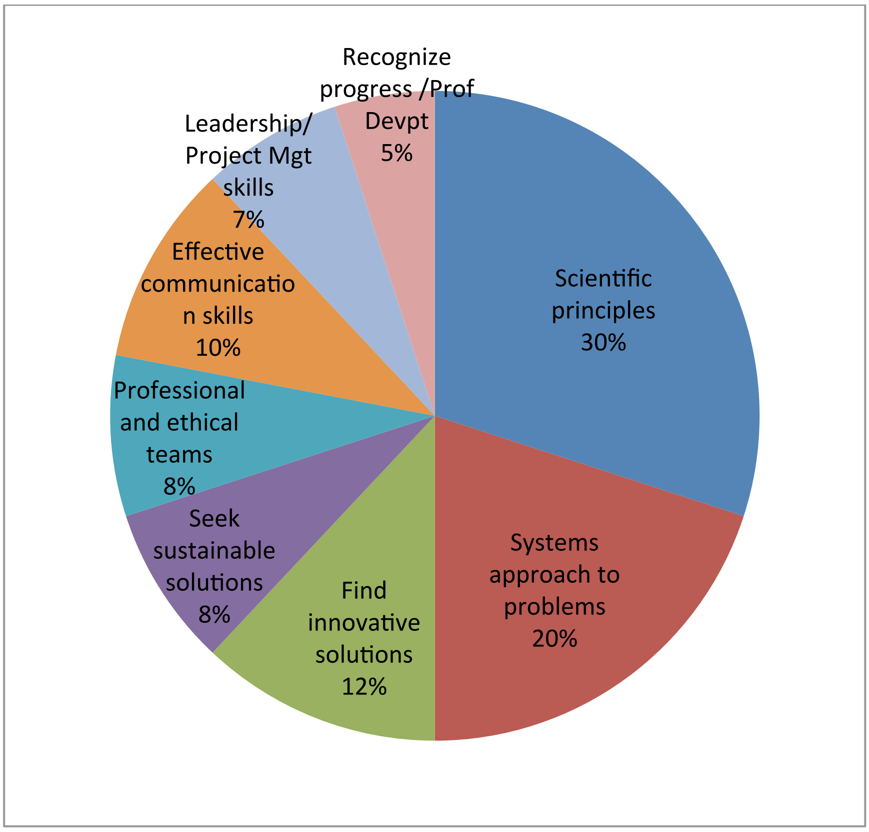

Fig.2. Content emphasis – Engineering programs at WSU

Table 2. Proportion of CLOs Mapped Against ULOs (Core Units Only)

CLO #	CLO Description	Content Proportion (%)
1	Knowledge of scientific principles	30
2	Systems approach to problem solving	20
3	Research skills	12
4	Seek sustainable solutions	8
5	Teamwork skills	8
6	Communication skills	10
7	Leadership and management skills	7
8	Recognition for and commitment to CPD	5

6. Conclusions

The CMT was proven to be an invaluable tool in the development of the suite of engineering programs that satisfied all the EA Stage 1 Competency Standards while also satisfying all the Western Sydney University graduate attributes. The tool helped in scaffolding student learning as they progressed through their chosen program. The tool also enabled the program designers to clearly visualise the need for change and enhancement in different components without having to dismantle all the subjects in the program. The design process was smoother and all the desired outcomes were achieved.

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Collaborative Project Based Learning in Novel 3D Printer Design

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Abstract: This paper is a report on a comprehensive Problem-based learning (PBL) approach, applied in the frame of a final year project, in the study of Advanced Manufacturing and Mechatronics at RMIT University, and in collaboration with the industry. The main project objective, from the engineering point of view, was the development of a new product, 3D Printer for metal printing. From the engineering education point of view, we had problem definition, project organization and management, theory and practice integration, participants' directions, multidisciplinary team approach, collaboration and feedback at various levels and institutions. Additive manufacturing, or 3D printing, is emerging as a technology that is already changing engineering and manufacturing. Currently extensively used in prototyping, 3D printing practice is becoming more interesting with a wider choice of materials available. Company SPEE3D developed a process known as SPEE3D print, which enables metal components printing at higher speeds compared to conventional powder bed metal printers. RMIT University and SPEE3D have already established collaboration across a number of projects. Multidisciplinary projects are in the areas of robotics, mechatronics, industrial design, computational fluid dynamics and schlieren photography. The project presented here, was funded by Future Designers Grant from the Department of State Development, Business and Innovation, Victorian Government, Australia. Final product, new 3D printer, designed by students, has received a Bosch Venture Forum Award in Germany, in June 2015. This was a great international recognition of PBL student centred approach, applied in our engineering education practice, as well as University and industry collaboration, supported by Government funding.

Keywords: PBL, collaboration, 3D printing, additive manufacturing, student centred learning

1. Introduction

RMIT University is one of largest Australian Universities with international recognition for excellence in professional and vocational education, research and collaboration with industry and community. As a dual sector University, RMIT includes project based learning as a contributing factor to all engineering graduates' work readiness, as requested by Engineers Australia (M Jollands, Jolly, & Molyneaux, 2012). It supports this through a large variety of its programs, resources and collaboration with the industry. University has one of Australia's leading 3D printing facilities, the Advance Manufacturing Precinct (AMP). It is used for the teaching and research across multidisciplinary areas, schools, industry, medical science, art and design, architecture and others.

University is working closely with a huge number of collaboration companies, starting with large companies like Boeing, Siemens, ABB, Telstra and many others, up to the small, start-up industry players. Large number of successful collaboration were already reported (P.T.J., Simic, & Dawson P, 2008; Simic & P.T.J., 2008). This practice continuous and improves each year. Finally there is

Government involvement with financial support to both the University and industry, when they expressed interest to work collaboratively (Simic, 2004, 2006; Simic et al., 2006).

SPEE3D is a new company established to change the face of manufacturing by developing a novel high speed, metal printing 3D printer. Start-up companies such as SPEE3D can iterate quickly, developing new ideas, testing and implementing results. Expectations are based on licencing and patenting already approved. These companies, however, generally have limited resources and funding. Working together with the University, the company helps in developing engineering students' graduate attributes, as defined by Engineers Australia, understanding of manufacturing and sustainability using real life projects (Margaret Jollands & Parthasarathy, 2013).

The skills and resources of RMIT and SPEE3D are complementary and provide an excellent opportunity for collaboration in developing new technology. The project "*A multi-disciplinary design approach to identifying growth opportunities in 3D printing*" was supported with a Future Designers grant, by the Victorian Government, and has continued on, following the completion of the grant. The project was multidisciplinary with the involvement of academics and students from different areas, such as, mechatronics, industrial design, business, computational fluid dynamics, robotics, mechanical engineering and computer science.

2. Project Management

Following reach collaboration, already realised in large number of successful engineering educational projects, a joint team put a Victorian Government grant application and the end of 2014 academic year. The main project objectives were to solve the problems that prevent metal 3D printing from becoming a true advanced manufacturing technology. Expectations were that SPEE3D's new technology will allow metal 3D printing at the faster speeds than the speeds achievable using existing 3D printing techniques.

The project had a number of distinct phases as shown in Figure 1. Successful grant opened the door for more meaningful cooperation, project based learning for students and business development for industry partner. While collaboration team was responsible for the whole project, including all tasks from 1 to 16, students' PBL projects were conducted in the framework of tasks 6 to 14.

This complex project was initially broken down into a number of subprojects to deal with industrial design, mechanical, mechatronic design and business planning. Of particular importance for both the industry partner and University was the grant constraint in time. Whole development with the design, test and build phase had to be completed in only 12 weeks. Successful completion of these elements allowed demonstration of the technology and follow up projects in the areas of robotics and printer head design/testing. The first prototype of the printer was designed using Computer Numerical Control (CNC) technology. Second generation was later designed using robotics. It was another multidisciplinary, multi-schools and industry collaboration project.

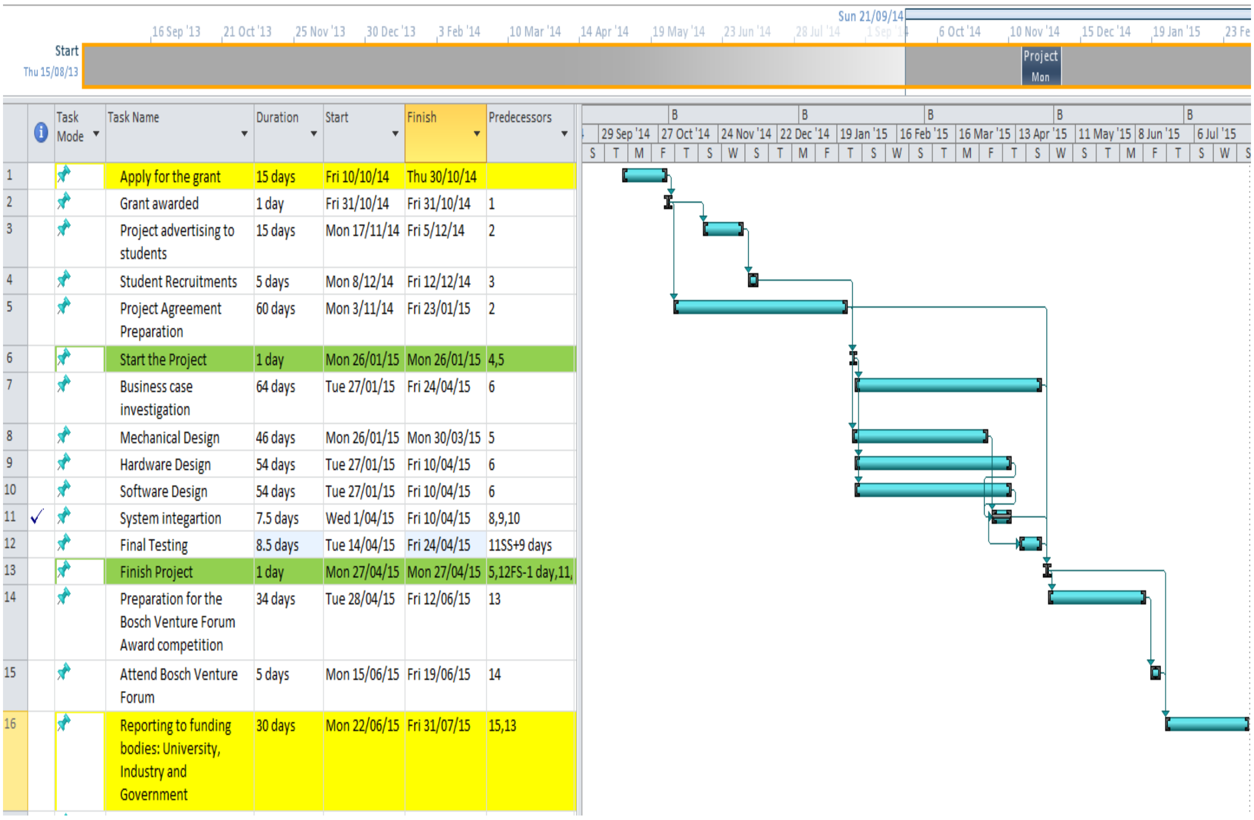


Figure 1 Novel 3D printer design project Gantt Chart

3. PBL Projects for Students

Using a Future Designers Grant awarded by the Department of State Development, Business and Innovation, Victoria, RMIT University and SPEE3D developed a breakthrough in 3D printing technology. An academic supervisor from the School of Aerospace, Mechanical & Manufacturing Engineering (SAMME) led the RMIT team and whole collaboration team. Students from different schools were working closely with the industrial partner's team under the supervision conducted by company's Managing Director and academic supervisor.

First of all, Mechatronic and Industrial Design students worked with academic supervisors alongside with SPEE3D personnel in developing a proof of concept printer. Business students, with their academic and industry supervisors were working on a commercialisation plan expressed in that task 7 which was "Business Case Investigation".

- Task 7 was seen as PBL project for Business students and for the students studying Master in manufacturing Management.
- Task 8 together with the tasks 11, 12 and 13 were core of the PBL projects for the students studying Mechanical Engineering and Industrial Design.
- Tasks 9-13 were core for PBL project conducted by Mechatronics students.

This approach to multiple, concurrently running students' PBL projects enabled start-up company SPEE3D to develop and test key components of the new technology. The company mapped out a path to take the business opportunity to the next stage.

The approach of breaking the larger project into short, concurrently running, sub-projects was vital to the success of the whole project. Students' PBL projects had time allocation of exactly 12 weeks, in total, as per Agreement between Government, University and Industry. Please see tasks from 6 to 13. With such a tight timeline, defined by the Government, high risk design elements were identified up front and strategies put into place to solve these issues. Students were selected that had background in design, and manufacture of industrial components, which enabled a quick ramp up time. The following chapters present the key project, i.e. sub-projects design elements.

4. Mechanical Design

Nowadays, nearly all engineering project are multidisciplinary. RMIT's Industrial Design School was approached for the design of external and functional elements of the printer. Key specifications for mechanical / industrial design included following requirements:

- Aesthetic and overall sound design – including material and part loading and unloading, sound proofing, ancillary component location, user interface and of course Occupational Health and Safety (OHS).
- Ease of manufacture – design and build to be complete within defined timeframe
- Low cost – project budget required a low cost prototype design.

The basic body building blocks were selected first. Mood boards were presented followed by overall concept sketches. Examples of these are shown in Figure .

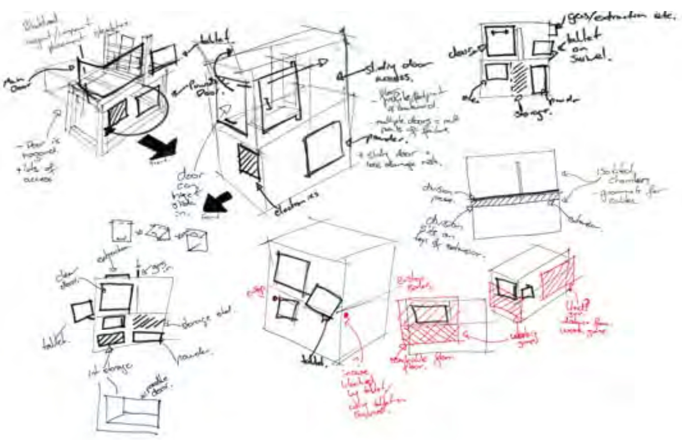


Figure 2 - Printer Industrial Design – Mood board and Concept Sketches done by students

The design was iterated from the initial concept sketches throughout the project length. Final renders, i.e. actual machine body is shown below in Figure 3

Figure 3 – Industrial design final outcome – 3D Printer body

Finally, all industrial design elements were created by a final year student from the Design School. Following the completion of the grant, SPEE3D Company has employed the student, now designer, for a 2nd generation printer design. This is the way how student's PBL final year project is converted to employment.

Mechatronic Design through Hardware and Software PBL

The most important subproject, i.e. students' PBL, for the success of the new printer development was the mechatronics design. Mechatronics includes mechanical, electrical, electronics and computer science design that can bring life to the engineering constructions. A final year mechatronics student was engaged to take care and design the following elements and sub-systems:

- selection of motors as actuation devices
- sensors selection for data acquisition (DAQ)
- control design and electronics
- selection of software and software design environment
- design of mechanical components including bed, frame and associated hardware
- programming of software
- sub-systems assembly and whole system integration
- final testing of the hardware and the whole system.

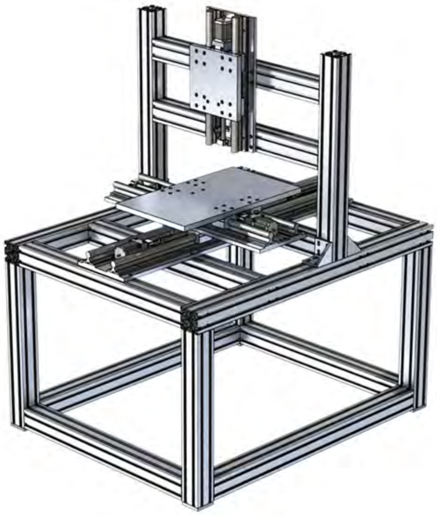


Figure 4 - Mechanical Design – Internal frame of the printer with CNC setup

Because of the relatively short project time emphasis were placed upon short lead time and readily available components.

Print Head Design and Testing

The heart of any 3D printer is its nozzle. It is a micro jet engine that is shooting metal particles in our case. Outside the Future Designers grant supported activities, equally important was the development of the printer nozzle. SPEE3D team was working with a Masters student from School of Engineering to model the nozzle using computational fluid dynamics. Results from this investigation have showed trends expected from the design. Figure 5 shows particle stream simulation results obtained by the application of computational fluid dynamic. The main objective was to achieve minimum dissipation of the material outside of the small targeted area.

A nozzle sub-system was subsequently built and successfully tested in the proof of concept printer. To validate the design and visualise the gas flow, Schlieren Photography was used. This involves the use of a light source, two mirrors and a high speed camera as shown in Figure 6.

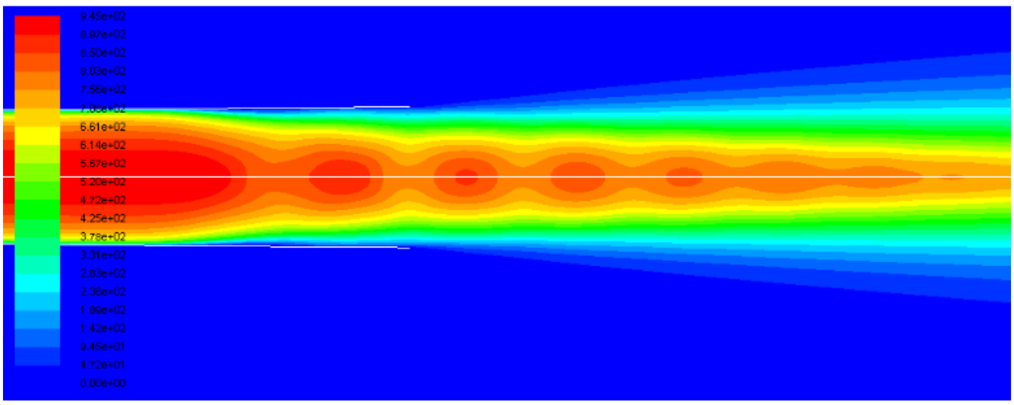
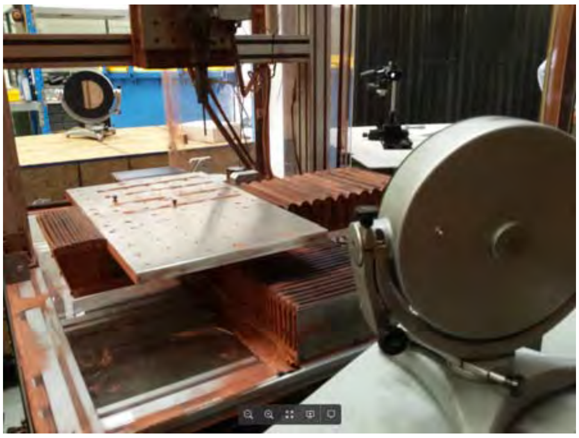
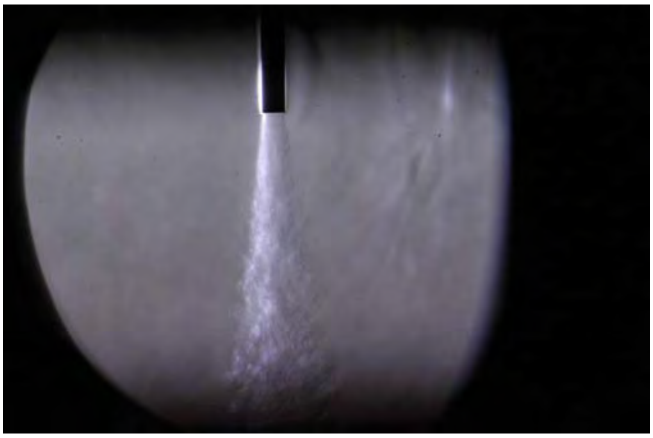


Figure 5 – Results from computational fluid dynamic presentation of particle stream

University has provided the equipment and academic/student knowledge to assist in capturing images, as shown in Figure 6b.





a) Lab setup b) Gas flow image

Figure 6 – Schlieren photography setup and gas flow image captured

5. World Recognition of RMIT University Work Integrated Learning

Every year Robert Bosch Venture Capital (RBVC) holds an event where a hand-selected group of applicant start-up companies are invited to the world headquarters of Robert Bosch in Stuttgart. They have to present their new technology ideas to senior management. RBVC is the corporate venture of Robert Bosch GmbH, one of the largest private companies in the world with more than 360,000 employees. Our new technology was presented and recognised in June 2015. Industry partner, SPEE3D, was presented with the Bosch Venture Award by RBVC, demonstrating the success of the joint University / Industry project, supported by a Victorian government grant. Core activities and whole product development was mainly conducted by our University students. It is great world recognition of Australian Engineering Education.

6. Conclusion

This project is an excellent example of collaboration between a start-up company and an established University under the support from the Government. Keys to success were short, sharp, focused sub-projects and understanding the strengths of the two parties involved. The University has expertise and facilities outside the scope of any start-up businesses, however, collaboration enabled excellent results for the company, students, University and the community. A small grant has initiated long term collaboration, which still continues, in the development of new technologies and practical, real life Engineering Education.

Acknowledgements

The authors acknowledge the grant funding by Future Designers Grant from the Department of State Development, Business and Innovation, Victorian Government, Australia. We also acknowledge University and industry contribution in the equal fund quantity amount. Finally, we acknowledge students had work and Award received.

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Enhancing Learning Experience by Collaborative Industrial Projects

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Abstract: This paper presents how collaborative industrial project are embedded into engineering curriculum at two departments: School of Science and the School of Engineering, at RMIT University, Australia. We introduce general structure of the industrial projects as Work Integrated Learning (WIL) modules, as well as provide a number of examples of recently completed projects.

Industrial summer projects, which were running in the years 2015/16 in collaboration with ANZ, ABB, Alfred Hospital, etc., were pipelined with final year projects from the School of Engineering as well as with the Software Engineering Projects (Bachelor and Master level) from the School of Science. The goal of these projects was to enable continuity of activities as per industry requirements and enhance learning experience, as well as, employability of the students. All the projects were successfully completed, also receiving positive feedback from industry partners. Some of the projects led to student's employment within the companies that have sponsored the projects.

With this approach, Future Designers Grant from the Department of State Development, Business and Innovation, Victoria, was efficiently implemented and a new product developed. After receiving Bosch Venture Forum Award in Germany, in June 2015 industry collaboration has extended to new partner, School of Science and activities continued over the summer. New design is implanted as well as large number of improvements.

Keywords: Learning Experience, Industrial Projects, Collaboration, Work-Integrated Learning

1. Introduction

Software Engineering (SE) is one of the most rapidly evolving and changing disciplines, which also influence the industry requirements on the skills that students need to obtain in universities for successful employment: some knowledge on SE might be extremely important in one decade and not required over the next years, cf. (Frailey, 2014). One approach to ensure a better experience and activate students in learning of Software Engineering (SE), is to focus on active and inductive learning, as this would provide a better understanding of what exactly SE really means and why there is a need for SE in the industry, cf. (Sedelmaier and Landes, 2015; Prince and Felder, 2006).

Sedelmaier and Landes (2014) provided justification from a pedagogical point of view that project-based learning (PBL) allows not only to gain technical knowledge in the related area, but also foster soft skills. Dagnino (2014) presented a method derived from the collaboration between North Carolina State University and ABB. This method brings diverse techniques to simulate an industrial environment for teaching a senior level Software Engineering course. In this paper we present our methods on enhancing learning experience, focusing of final year SE students at RMIT

University, Australia. In contrary to the approach of Dagnino (2014), we do not simulate the industry environment for our projects, but use a real one, based on collaboration with local and overseas industrial partners. In addition to that, project based learning is seen as a contributing factor to graduates' better work preparation, cf. (Jollands et al., 2012). We have already presented a number of collaborative partnerships in engineering education, cf. (Mo et al., 2008; Simic, 2006), but in this case we have additional stakeholder. It is Government with its grant for the business and innovation. Another good example of Government support for engineering education is in the design of flexible entry pathways to Mechatronics / Robotics profession as previously reported in (Simic, 2004).

2. Work Integrated Learning within Software Development Projects

The Computer Science and IT department of the RMIT School of Science has a long history of Work Integrated Learning (WIL) activities used to improve the learning experience of students. Software Engineering projects are conducted in collaboration with industrial partners. In this paper, we present two types of these activities, *YourSoftware* and Summer projects.

2.1 *YourSoftware* projects

YourSoftware projects were initiated by Astrid Bauers[1] more than 10 years ago, in 2005, as industry-based projects for Master of Software Engineering students. Currently the *YourSoftware* projects are provided as compulsory final year courses both on Master and Bachelor levels within the Software Engineering Program, and in Semester 2, 2016, we are going to allow enrolment into these courses also for Bachelor of Computer Science students as a "pilot study". These projects provide, to RMIT students, a hands on practical experience in developing software within a real project environment, having meetings with stakeholders and the corresponding mentoring, as well as experience in a team work on larger projects.

YourSoftware teams consist of 4 – 6 students, where the size of the team depends on the project scope and number of students enrolled into the courses. Allocation to the teams is bases on students' skills and preferences. Students work on the projects within a semester 13 weeks long for approx. 20-40 hours/week, depending on the courses they are enrolled in, which means that a team contributes in average 2,500 hours of work. The number of students enrolled in the corresponding courses grows over last years, e.g., from 87 students in 2013 to 124 students in 2015.

RMIT provides *YourSoftware* lab space to allow students to have an "office" where they can come to work in the team, either using the provided workstations (Windows and Mac OS) or their own laptops, as well as, the servers and software, supported by the RMIT technical services group. We also have a number of teams working in industrial environments, i.e. from the place of industrial partners. For example, RedBubble company[2] accommodates their teams in the RedBubble office space, to provide students more support and mentoring in a real working environment. Another option for students to work on real-life scenarios in an innovative environment is to use the RMIT VxLabs, cf. e.g., (Peake et al, 2015; Blech et al., 2015, Blech et. al, 2014, Spichkova et. Al, 2013), cf. also Section 4 for more details. The VXLab video wall is shown in Figure 1.

In Semester 1, 2016, we had 18 *YourSoftware* project proposals, and 12 of them got a team. The Project Proposal Sponsors of these teams are ANZ, Navy, Panviva, Bookon, RedBubble, Kaleido Labs, Carers Victoria, Bureau of Meteorology, Adeft Consulting Group, and Department of Justice

[1] https://www.youtube.com/watch?v=1FFw5CjMIsA
[2] http://www.redbubble.com

& Regulation. The majority of the projects focus on the development of either web/cloud-based systems or iOs/Android apps, cf. Figure 2.

The Department of Justice & Regulation project was focused on development of Android and an iOS apps, that are implementations of Intelligent Speed Adaptation systems to contribute to the road safety in Victoria, Australia. The apps are named *DriveVictoria*, as the case study was based on the information about the locations of the speed signs and the schools in Victoria. The corresponding data sets are accessible via VicRoads[3], the road and traffic authority in the state of Victoria, Australia, as well as Victorian Government open data[4]. This project was complemented by academic research, separated from the learning and teaching activities within the project, on intelligent speed validation and adaptation, cf. (Spichkova et al., 2016).

Figure 1. State of the art: RMIT VxLabs

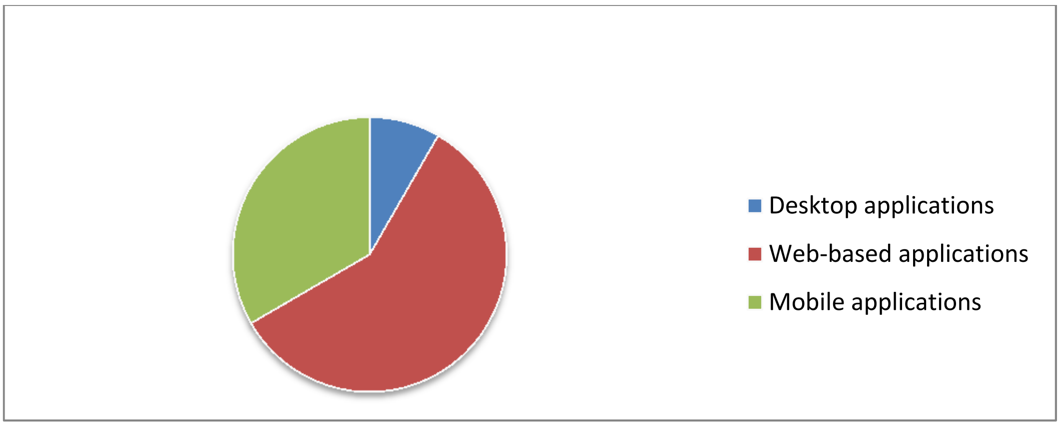

Figure 2. *YourSoftware* Projects (Semester 1, 2016): Types of developed software

[3] https://www.vicroads.vic.gov.au
[4] https://www.data.vic.gov.au

2.2 Industrial Summer projects

In 2015, we initiated Industrial Summer projects, to provide students the opportunity to gain the real-life industrial experience within the summer break 2015/16. Altogether, we had 40 student projects. 19 of them were industry led, involving 25 students and 10 academics. The industry partners of these projects were, for example, ANZ, ABB, Effusion, Alfred Hospital, Pop Tech, Compliance Group, Proximity, Future Grid, Gnosis Technology, Scientific Technology, SuperTooth, ICMTEL, etc.

After the Summer projects, two students received job offers from the companies with whom they completed the project. Like in the case of *YourSoftware*, the majority of the projects focus on the development of either web/cloud-based systems or iOs/Android apps, cf. Figure 3.

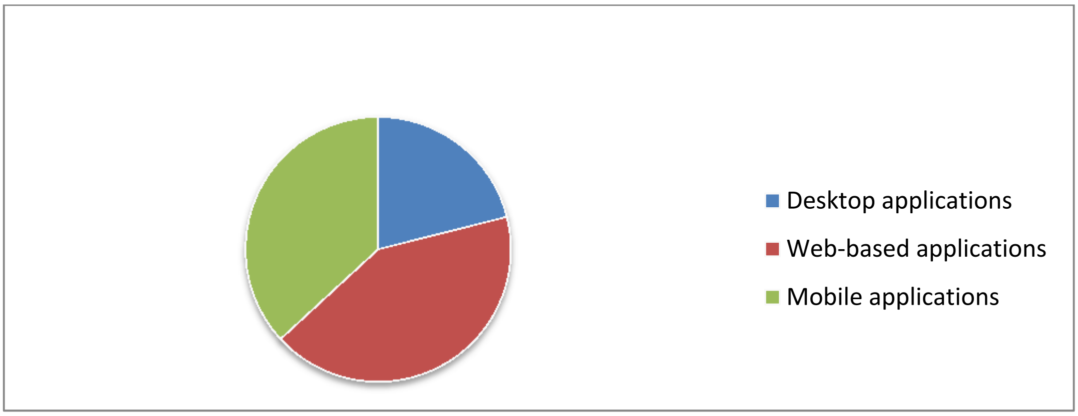

Figure 3. Industrial Summer Projects: Types of developed software

3. Future Designers

During the first semester of 2015 a joint RMIT University and industry, Effusion, team has designed a new 3D printer for metal printing. Whole project was funded by a Future Designers Grant from the Department of State Development, Business and Innovation, Victoria, Australia. This multidisciplinary project was structured as number of PBL projects conducted by Mechatronics Engineering, Design, Business and Management students. In June 2015 team has received Bosch Venture Forum Award in Germany. Robert Bosch Venture Capital (RBVC), is a private company that supports start-up companies across the world. Novel 3D printer is shown in Figure 4 (a), while Bosch award is presented in Figure 4(b).

The work was performed with the intention of developing a new application of the 3D printing technology in advanced manufacturing. RMIT team was working with industry experts from Effusion Company, while RMIT University has supplied all necessary resources.

After the first generation of the 3D printer was designed and awarded, collaboration was continued and extended to Computer Science and IT department of the RMIT School of Science. Instead of the application of Computer Numerical Control (CNC) type of solution, decision was made to introduce a robotic arm as shown in Figure 5. This new PBL or WIL project was now conducted using resources from the Computer Science and IT department, as an industrial summer project. After successfully finalising project work student was offered the job to stay with the company. Industry partners are exercising this practice very often which is extremely important for the students, academia and community.

(a) Novel 3D printer (b) Bosch Venture Award

Figure 4. Future Designers Project

Figure 5. Robotics in Novel 3D printer design, second generation

4. VXLab

The Virtual Experiences Laboratory (VXLab) at RMIT is a virtual, distributed laboratory connecting industrial automation and visualization facilities for research, innovation and teaching. The VXLab has invested in platform technology in industrial automation, visualization and user interfaces and services/clouds, targeting industry and research collaborations in for example manufacturing 4.0, sensors, analytics, internet of things, virtual and augmented reality, serious games and global collaboration. We aim to create a virtuous cycle of opportunities for cross-disciplinary research and innovation, which is attractive to industry, researchers and students. Further advantages include the prospect of providing remote access to automation facilities to students off-site, or without “suiting up” with personal protective equipment.

The VXLab consists in particular of a networked ABB robot lab, large tiled video wall running SAGE2[5], and the Virtual Experience Portals (VxPortals). The VxPortals are an ultra high-definition, head-tracked 3D visualisation platform developed jointly with the Centre for Games Design Research (Peake et al, 2016). For teaching in particular we are targeting industry-connected and cross-disciplinary experiences including through funded projects and industry-provided academic facilities such as IBM’s Bluemix platform. Each of these projects involved participation

[5] sage2.sagecommons.org

either by RMIT researchers, or with some input from an external organization, or both. Typically supervisors and researchers are from the Australia-India Research Centre for Automation Software Engineering (AICAUSE), which is a partnership between RMIT and ABB, a multinational power and automation company.

Among the student projects which have been run in the VXLab since 2014 are[6]:

- Teaching robots using air commands remotely (TRAiCE) - summer studentship integrating ABB IRB120/IRC5 with Leap Motion hand tracking sensor via Unity3D
- Social media for robotics - capstone project integrating Collaborative Engineering research platform with twitter API (with AICAUSE supervisor)
- Telerobotic cloud – internship integrating of ABB IRB120/IRC5 with Leap motion hand tracking sensor and cloud-deployed OpenCV component
- Point cloud analysis for robotic feedback – capstone project using Microsoft Kinect sensor (with RMIT Architectural Robotics Lab)
- Making sense of open data using IBM Bluemix - summer internship based on Javascript and Bluemix technologies (with requirements stage participation by Melbourne City Council CityLab) [Figure 6]
- Robotic 3D printing Prestudy using ABB robots (with Effusion)
- SmartSpace 3D - visualisation of Smart Grid data from SmartSpace research platform via Virtual Experience Portals [Figure 7] (ABB-sponsored, with AICAUSE co-supervisor)
- Augmented reality for manufacturing quality control using mobile web technologies (with AICAUSE co-supervisor)
- Using Kinect sensors for feedback in manufacturing quality control (with AICAUSE co-supervisor)

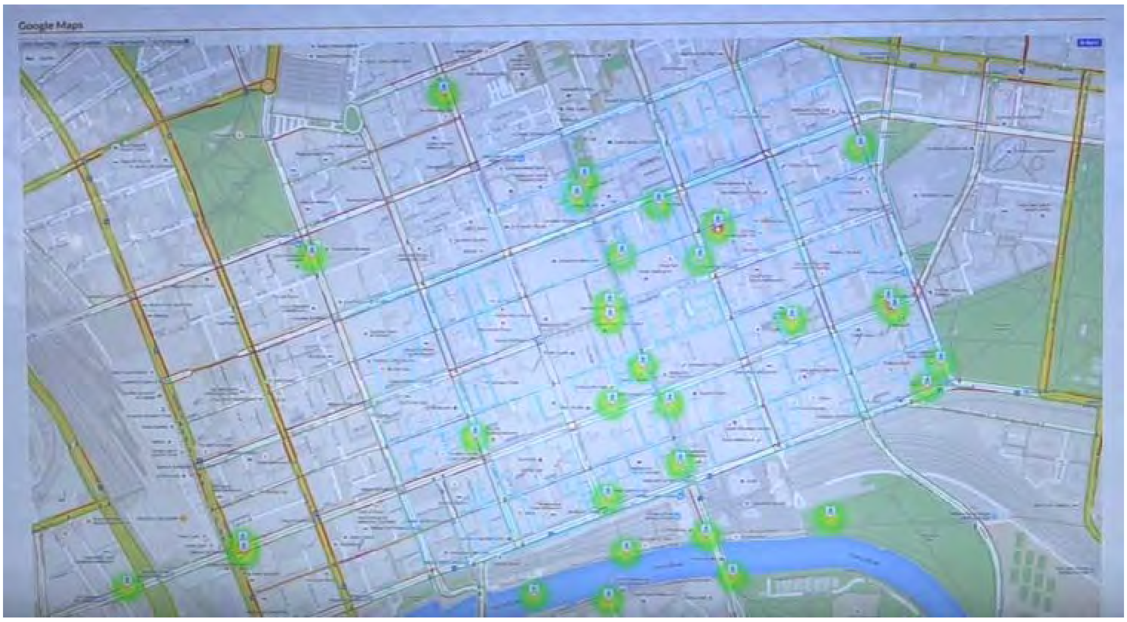

Figure 6: Open data mashup of pedestrian and parking data with IBM Bluemix

[6] Many of these projects have been documented (e.g. via short video clips) at: https://plus.google.com/111014608163834449893/posts

Figure 7: SmartSpace 3D (ABB-sponsored internship)

5. Conclusions

RMIT as a dual sector University strongly encourages Work Integrated Learning, i.e. Project Based Learning. In order to achieve that it has established strong links with industry and government institutions for many decades. Each engineering within the University nurture large variety of collaborative industrial project as presented here. Projects are always multidisciplinary since technology and engineering are becoming comprehensive and integrated. Very often those projects receive local community recognition, but they achieve international recognitions as well.

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Hydrology Education: Challenges and Future Directions

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Abstract: The twentieth century witnessed great progress in hydrology, from two different perspectives: (1) population explosion and its many water-related consequences (e.g. increase in water demands, degradation in water quality, increase in socio-economic costs of floods and droughts) necessitated better education, research, and practice in hydrology; and (2) technological and methodological developments offered many useful tools and ways to study hydrologic systems. Despite this progress, there remain many weaknesses and challenges in hydrologic teaching, research, and practice. For instance: (1) hydrology education continues to largely ignore some topics of water that are vital to society, such as water security, crisis, conflicts, policies, and governance; (2) there is a tendency to gain 'specialization' in some aspects of hydrologic systems/mathematical techniques rather than to look at the 'big picture;' (3) a generic framework for hydrologic modeling (especially one that has great practical relevance and one that can also be easily implemented) is still missing; and (4) efforts to communicate hydrology to researchers in other scientific fields, and to the broader society, towards a truly interdisciplinary study on water are clearly lacking. The present study aims to discuss these issues and propose new strategies to advance hydrology further.

Keywords: Hydrology education, water security and policy, generic modeling framework, communication and training

1. Introduction

Water is a vital resource on this planet that is very much needed for the survival of human beings. It is a key resource in the production of commodities and an essential component for the maintenance of ecosystem health (Liu et al., 2014). Singh (2008) noted that "millions of people on this earth live without love and affection, but no one can survive without water even for a few days".

Biswas (1970) stated that the history of mankind can be written in terms of human interactions and interrelations with water (Biswas, 1970). Most of the ancient civilizations were established along major river courses, such as the Nile, Yellow, Ganges, Euphrates and Tigris. At the same time, many old civilisations were collapsed due to poor water management. As an example, the Sumerian empire collapsed mainly due to excessive irrigation salinity. It has often been stated that "water will be the oil of the twenty-first century" (Annin, 2006).

In Australia, water has a special place in its society, as it is the driest inhabited continent on earth, it suffers from catastrophic floods on one hand and long-lasting droughts on the other hand. Water is vital for Australia's agricultural production, which is a major sector of its economy (Rahman, 2016).

Water is the subject of study in many fields of knowledge. For example, water is mentioned in poems across many world literatures as well as it is a major topic of study in engineering and sciences. In Civil Engineering, water is taught as part of number of subjects including Fluid Mechanics, Hydrology, Hydraulics, Hydrogeology and Water Resources Engineering. This paper discusses how Hydrology is taught currently in universities. It argues that the syllabus of Hydrology subject needs an overhaul to reflect the societal aspects of water under changing climate regime and eco-hydrologic needs.

2. Current Hydrology Syllabus

At present, Hydrology subject in universities focuses mainly on mathematical aspects of water quantification. It covers water balance, rainfall runoff modelling, flood frequency analysis, groundwater, rainfall estimation, rainfall and streamflow measurement and few other topics such as urban hydrology. It is offered mainly by face-to-face delivery consisting of lecturers, tutorials, projects and field studies. However, blended learning is becoming popular with Hydrology similar to many other subjects. The current syllabus of Hydrology lacks in societal and management aspects as noted in the following section.

3. Suggested Upgradation of Hydrology Syllabus

There remain many weaknesses and challenges in hydrologic teaching, research, and practice. For instance: (1) hydrology education continues to largely ignore some topics of water that are vital to society, such as water security, crisis, conflicts, policies, and governance; (2) there is a tendency to gain 'specialization' in some aspects of hydrologic systems/mathematical techniques rather than to look at the 'big picture;' (3) a generic framework for hydrologic modeling (especially one that has great practical relevance and one that can also be easily implemented) is still missing; and (4) efforts to communicate hydrology to researchers in other scientific fields, and to the broader society, towards a truly interdisciplinary study on water are clearly lacking.

4. Conclusion

Hydrology is an important subject in engineering. However, the Hydrology syllabus has not been upgraded significantly in recent years to meet the current societal demand. This paper has briefly touched this important issue. At present, Hydrology course mainly focuses on mathematical aspects of water quantification. Hydrology syllabus should include topics such as water security, crisis, conflicts, policies and governance as well as impacts of climate change on water, social hydrology and eco-hydrology. In terms of delivery of hydrology subject, blended learning approach can assist effective delivery of the course contents to students as it offers greater flexibility in learning and teaching via online materials such as recorded tutorials, video clips and online quizzes.

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Entrepreneurship Capstone Design Project: Introducing Local Community-University Cooperation Model in South Korea

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Abstract: In South Korea, it engaged in policies that foster technology-based start-up in order to strengthen national competitiveness. To this end, the Ministry of Education prepared the 'University Founded five-year plan' aiming to meet the creative talent in the creative economy and it has spread entrepreneurship education in entrepreneurship culture in universities. Technology-based Entrepreneurship training at the university entrepreneurship education can be realized in conjunction with engineering education. Through the example of Dongguk University, we will introduce on entrepreneurship capstone design project adopting the local community linked university cooperation model

Keywords: Local community - University Cooperation, Technology-based Entrepreneurship, Entrepreneurship capstone design

1. Introduction

Korea needs a new foothold for growth to activate the local society through converging science technology and ICT for the era of 'creative economy'. To invigorate local commercial supremacy and traditional market, which are in relatively poor conditions, there needs to be a new approach combined with creative idea based on challenging entrepreneurship of young people (University students) to attract young generation. Further, education through participation in the actual industry (society) and activities are becoming important for nurturing convergence type creative human resources which are required for employment, start up, and job creation for engineering and foundation educations in the University. Started from engineering education, therefore, convergence capstone design programs, along with capstone design courses carried out in individual course of the entire Universities, are being opened. This article examines development and cases of convergence type start up capstone design education program which is for participation in local society to provide countermeasure for the multi and interdisciplinary students of Dongguk University to have social entrepreneurship.

2. Entrepreneurship Capstone Design Linked to Local Society

2.1 Background

Literally, Capstone refers to curbstone or perpend which are located on the top of wall, pillar or structure in construction and are decoration and symbol as well. Wagenaar(1993) has defined capstone as a course which makes students to experience making decision through convergence to

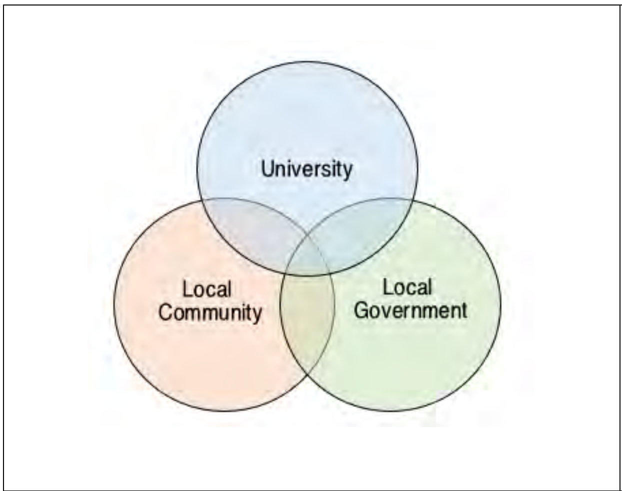
detailed research through expanding, criticising and applying knowledge obtained from each major. Further, Davis(2004) has defined this as the final maturing experience. Murphy(2003) has defined this course as a subject dealing with types of questions and main issues of the field by focusing on how to obtain academic knowledge to help students understanding connection between various courses. Further, he said that this course can be the turning point for students to move from academic field to occupational field. In addition, Moore(2004) has argued that this course connects what students learn from their majors. Further, he has said that this course links expectation of the society on the education and mission of Universities and mission of major education programs.
As shown, Capstone design has started from engineering and is currently making students to experience all processes from design, development and manufacturing of products based on convergence knowledge of humanities, society, art. Further, it is being developed as a course to have field-work capability, team work and leadership.

The Objective of this course is for students to have capability for comprehensive designing and project development by experiencing actualization of the obtained knowledge as the measurement for development of project through the course. Further, students can train creativity, capability for actual work, team work and leadership through solving out tasks of businesses by themselves and transfer technology by which the businesses require and find jobs.

2.2 Development of Leading Model

Dongguk University is a 4-year private university located in the center of Seoul, the capital city of South Korea and has 110 years of history. Currently, it consists of 11 colleges with 57 departments, and the number of students accounts for as to 12,000. Dongguk University has long history in the field of humanities and art. Recently, however, its academic areas are being expanded centered at engineering majors and consequently, number of students and professors occupy 1/4 of the entire university. The Dongguk University's LINC project team, accordingly, has set the project vision as 'Building urban & global industry-university cooperation system through convergence of humanities, art, engineering and entrepreneurship'. The LINC project team of Dongguk University consists of industry-university HR training center, industry-university enterprise support center, field training support center, entrepreneurship center, D-CUBIC specialization center, and administration office. In addition, 19 departments (major) of 8 colleges and about 6,000 students participate in this project.

Dongguk University's LINC team has proposed a new type of University-Industry leading model which is linked to the local community.



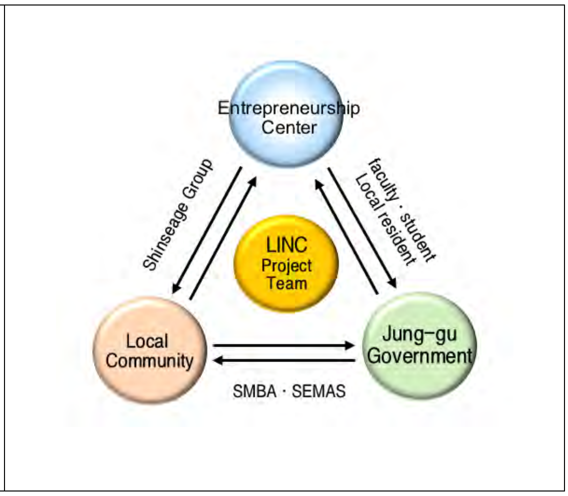


Figure 1. New University-Industry Model Linking to Local Community of Dongguk University

According to this plan, the team has built execution system with the stake holders of the local community centered at Entrepreneurship Center of Dongguk University. Further, the team has established a project team consists of Dongguk University, which is located in Junggu of Seoul, Junggu Office, which is the local government, CSR team of Shinsegae Group, local market association and local residents.

Table 1. Course Carrying Out Logical Model

Input	Process	Output	Impact
Start-up linking to local community Capstone design regular lecture Convergence + Start-up Participation of students at the University Level Participation of all professors Participation of professionals from outside	Cooperation from stake holders Participation of related organization Investigating and selecting the target place Commercial supremacy of Chungmuro c(2015) Tongin Traditional Market (2015)	Creation of excellent cases Establishment of start-up society Application of intellectual right Linking employment and start up	Creation of creative University-traditional market leading model. Development of 2015/2016 market-University cooperative project Spreading results to participating Universities (25)

In this course, students perform tasks by utilizing multi-disciplinary knowledge based on engineering of young people (University students) those who are members of the local community as well as the traditional market. This is an educational course which the students care about actual problems of the local markets, choose issues and solve the problems by utilizing appropriate technology and knowledge.

Table 2. Course Carrying Out Constraints & Overcoming Factors

Error Factors	Process of Overcoming
Complicated problems of activation of local markets (traditional markets) - Relatively poor commercial supremacy of the original city - Various needs of individual merchants - Old merchants and lack of will for participation in the project Absence of professionals and professional curriculum Absence of recognition of the needs of lecture on convergence capstone design Difficulties in measuring promotion and performance of participating students	Youth entrepreneurship center will take charge at the University level. Linking University-level participation to start up education→Professors who have professional capability and related experiences (Engineering + Design + Start up/Industry-University Cooperation professors) establishment and participation Participation of professional mentor from outside Regular grade system (3 grades) Related organization (SMBA, SEMAS), cooperation with members of the local community (local government, merchants' group and local residents, selection of target area

The details of education measurement are as follows.
(Objective) Relevant professors, market supremacy professionals and merchants association participate in all procedures of students' project from goal setting (recognizing problem, selection of topic) to production (prototype), application of intellectual right, test and evaluation.
(Operation) The goal is to have activities and measurement for learning and problem solving (opportunity for mentoring by which professionals of the field provide) for having social entrepreneurship through more than 10 times of field visiting, workshop (competition) of each team including special lecture from professionals, entrusting responsible mentor (professionals of each project team for the field), weekly team activity evaluation, mentoring and meeting.

Table 3. Syllabus for Course

Course Design	Linking to 1 year (2nd Term), course design, reflection of regular grades
Form of Lecture	Theory + field work (centered at field work)
Professional Lecturers	Instructor (professors) and lecture by professionals from outside for each team.
Lecture Design	Development of professional curriculum
Participating Students	Multi-disciplinary students of entire university and team configuration
Activity Evaluation	Stake holders participating in lecture (professors, local government, market merchants association)

3. Activities of Participating Students and Cases of Start Up

3.1 Development of platform for activation of local markets

(a) NASHS Co., Ltd Team

F&A service for consumers and small enterprises through 1:1 chatting, chatting service for reservation

Figure 2. NASHS Co., Ltd Team activity

(b) DAYFIT Team

The user can use allianced gym in the region anytime and anywhere (payment for each time)

Figure 3. DAYFIT Team activity

4. Conclusion

Dongguk University has proposed an alternative through cooperation with members of the local community centered at University linking problems of local society to social responsibility. Further, the organization has prepared a sustainable measurement, made work agreement for work for activation of the local economy and decided to build and a new related research center.

Further, the central government has developed 'Project for Creative Activation of Traditional Market' through utilization of creative ideals of students for activation of the local and traditional market through participation of 22 Universities in 2015. This project is spreading to the entire nation.

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Preparing Students for Engineering Success through Improving 3-D Spatial Skills

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Abstract: Three-dimensional spatial skills have been shown to be critical to success in variety of STEM fields. In particular, spatial skills have been linked to success in engineering and in learning to program in computer science. Unfortunately, of all cognitive processes, 3-D spatial skills exhibit some of the most robust gender differences, favouring males, which could have serious implications as we attempt to increase gender diversity in our engineering programmes. Spatial skills are not usually a part of the formal instruction in the pre-college classroom, meaning that many of our students enrol in our engineering programmes deficient in these skills. A course for developing 3-D spatial skills has been offered at various universities in the US over the past two decades. Outcomes for this course include improved grades and graduation rates for the students who participate in it, particularly for the women. Based on these successes at the university level, attempts are being made to incorporate spatial skills training into pre-college classrooms. The authors are involved in an international collaborative study regarding the impact of spatial skills training at the pre-college level. This paper describes the study in each country and also outlines key findings to date. The implications for engineering access and success will be discussed.

Keywords: pre-college engineering education, women in engineering, graphics and visualization

1. Introduction

Numerous research studies have shown the importance of spatial skills for success in engineering and other STEM fields. In particular, well-developed spatial skills have been linked to success in learning to use CAD software (Sorby, et al, 2014; Branoff, 2014; Hamlin, Sorby, & Boersma, 2006), creativity and technical innovation (Kell, Lubinski, Benbow & Steiger, 2013), solving conceptual circuits problems, (Duffy, Sorby & Bowe, 2016), learning to program (Jones & Burnett, 2008), and in solving typical physics problems (Talley, 1973; Kozhevnikov, Motes, and Hegarty, 2007).

The ability to visualize in three-dimensions is a cognitive skill that typically develops as a child reaches adolescence. There is little formal training in pre-college classrooms that guarantee that a child's spatial skills are fully developed. The spatial skills of women lag significantly behind those of their male counterparts (Tartre, 1990; Linn & Petersen, 1985; Voyer, Voyer, & Bryden 1995), which could have serious implications as we strive to diversify engineering. Women who have poor spatial skills may become discouraged in their engineering coursework, particularly in the introductory courses such as graphics or CAD, and leave engineering as a result of these poorly developed skills. No one knows for certain why these gender differences exist. There is some evidence that this could be related to male hormones (Hier & Crowley, 1982). Others posit that this is due to evolutionary factors with the idea being that hunters required good 3-D spatial skills but gatherers did not (Silverman et al., 2000). Numerous studies have also found that differences in spatial skills between the genders could be due to environmental differences (e.g., Fennema &

Sherman, 1977). Boys are more likely to play with Legos, build models, or play 3-D computer games—all activities that tend to help children develop their spatial skills. There is also evidence that there is an interaction effect between biological factors and environmental factors that leads some to posit that we start out with a small biological difference that is magnified and increased based on the activities we engage with as children (Casey, B. M., Nuttall, R. L., Pezaris, E., 1999).

Sorby has been involved for more than two decades with a course aimed at first-year engineering students designed to help them learn to visualize in three dimensions (Sorby, 2009). The course is a one-credit course (US system) that meets for 1.5 hours per week over a 14-week semester. The topics covered in the course include: surfaces and solids of revolution, combining objects, isometric sketching, orthographic projection of normal, inclined and curved surfaces, flat patterns, rotation of objects about a single axis, rotation of objects about two or more axes, object reflections and symmetry, and cutting planes and cross sections. Students use hand-held manipulative throughout the course and complete a number of sketching exercises as they work through the course material. Significant findings from this previous body of work include:

- Students' scores on a test of spatial ability improved substantially as a result of participation in the course. Average pre-test scores were ~50% and average post-test scores were ~80% across multiple years of data gathering. There were no significant gender differences for this group of students at either the pre- or the post-test (students enrolled in the course because they failed the visualization test), which means that the intervention helped the female students as much as it helped the male students.
- Average grades in a variety of STEM courses were higher for the students who participated in the intervention course compared to a control group of students who failed the spatial skills test but who chose not to enrol in the course. On average, the improvements in course grades were about one-half of a grade (e.g., a B+ versus a B). Grades in Calculus, Computer Science, Physics and Engineering were positively impacted by participation in the spatial skills course.
- Retention and graduation rates were higher for those who participated in the course when compared to the rates for students who did not participate in the course. Improvements for the retention/graduation rates for the women were particularly high. In one study, the difference was 77% versus 47%.

2. Current Study

At the university level, the spatial visualization intervention course appears to have a positive impact on diversifying engineering through retention of female students. However, this is probably not enough if we want to achieve true gender equity within the field—not enough women are initially choosing our programs. It could be that one of the keys to diversifying engineering would be to implement the spatial skills training at an earlier age. In particular, if spatial skills are critical to success in mathematics, perhaps implementing the intervention at an earlier age would facilitate improved performance in mathematics which would, in turn, lead to greater enjoyment of mathematics and eventually lead to more students, particularly girls, choosing engineering when selecting their university major.

In order to determine if spatial skills training at the pre-college level would have an impact on mathematics performance and interest in STEM careers, researchers in three countries are collaborating to conduct studies over multiple years. In the U.S., students in various 7th grade (approximate age=12) classrooms will complete the spatial skills intervention course; in Ireland, students will complete the training in their transition year (approximate age=16); in Australia, students will complete the intervention course in 10th grade (approximate age=16). The study reported on here is a multi-year effort o date we have merely collected baseline data from pre-college students in our respective countries. This paper will focus on the results from the baseline data collection to date.

3. Data Collection

Four tests of spatial ability were administered to our study participants. One test of spatial cognition was 10 items from the Purdue Spatial Visualization Test: Rotations. A sample problem from the PSVT:R is shown in Figure 1. With this test, students are presented with an object on the top line that is shown in both an original and a rotated position. On the second line of the problem, a different object is shown. The objective is to mentally rotate the second object by the same amount as the first object and select the result from the choices given.

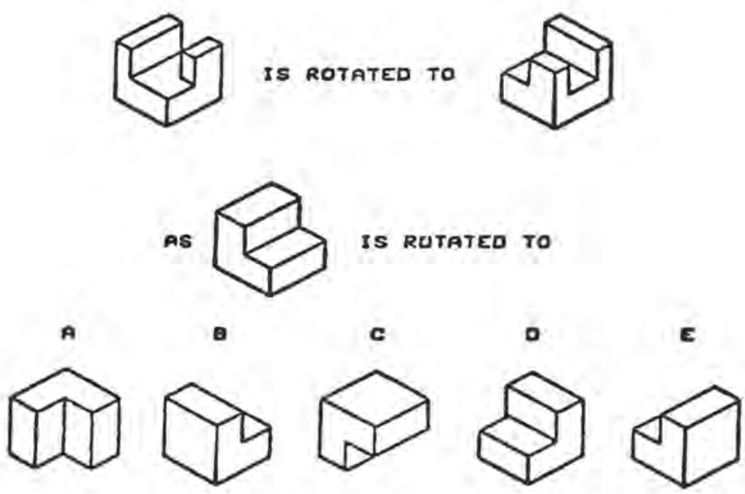

Figure 1. Sample problem from PSVT:R (Correct answer is D)

A second test of spatial cognition that was administered to the students was 10 items from the Differential Aptitude Test: Space Relations. A sample problem from the DAT:SR is shown in Figure 2. With this test, a flat pattern is shown on the left. The pattern frequently has markings or shading on parts of it. The objective with this test is to mentally fold the pattern up to form a 3-D solid and then to choose which of the objects presented represents the object that would result.

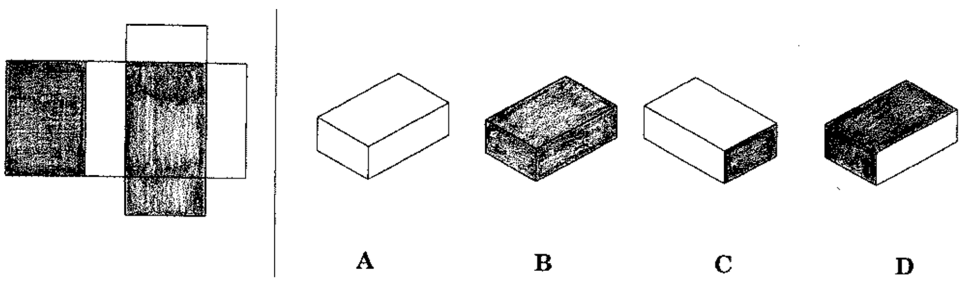

Figure 2. Sample problem from DAT:SR (Correct answer is D)

The third test of spatial cognition given to the students was ten items from the Mental Cutting Test. With this test, an object and an imaginary cutting plane are shown on the left. Students are asked to visualize what the cross-section would look like that was the result of intersecting the object with the given plane.

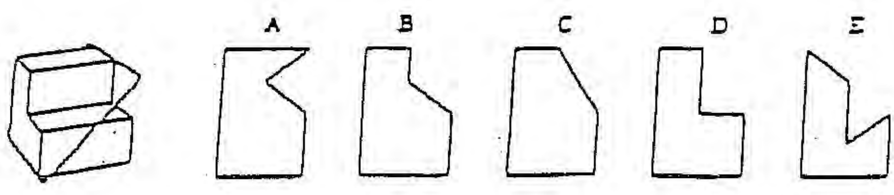

Figure 3. Sample problem from the MCT (Correct answer is D)

The final test of spatial ability administered to the participants in the study was the Modified Lappan Test. A sample problem from this test is shown in Figure 4. The test is used to determine the ability of the students to transition between 2-D and 3-D representations of objects.

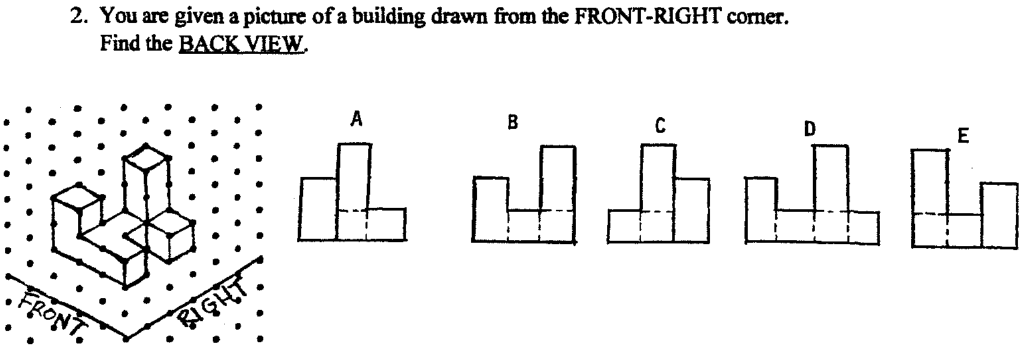

Figure 4. Sample problem from the Modified Lappan test (Correct answer is E)

4. Test Results

To date, the tests have been administered to approximately 1200 middle school children in the U.S. and to approximately 2500 first-year students in Ireland (approximate ages of both groups is 12 years old). Testing is planned in Australia in the July/August 2016 timeframe. Results from the testing in all three countries should be available in time for the paper presentation. It should be noted that not all tests were administered to all students in the study. In particular, all four tests were administered to the students in the United States but only three of the four (all but the Lappan test) were administered in Ireland.

In the U. S. the testing was accomplished in two waves. The first wave took place in ~October 2015 and the second wave in ~February of 2016; thus, we are able to determine if there was a growth in spatial skill levels over a 4-5-month period. Testing in Ireland took place between January-May, 2016. Tables 1-3 include the data from this testing.

Statistical Measure	All tests combined	DAT	PSVT	LAPPAN	MCT
Mean	0.31	0.39	0.33	0.25	0.26
Variance	0.2	0.22	0.21	0.18	0.18
Inter-item correlation	0.07	0.1	0.11	0.11	0.05
Cronbach's Alpha	0.76	0.53	0.56	0.53	0.33

Table 1. Results from Wave One testing in the United States (n=1249)

Statistical Measure	All tests combined	DAT	PSVT	LAPPAN	MCT
Mean	0.36	0.45	0.41	0.30	0.29
Variance	0.49	0.49	0.55	.042	0.28

Table 2. Results from Wave Two testing in the United States (n=606)

	Count	DAT:SR	PSVT:R	MCT	Total
Total	2464	39%	35%	26%	34%
Male	1215	41%	38%	26%	35%
12yo	193	39%	35%	25%	33%
13yo	927	40%	38%	26%	35%
14yo	95	44%	39%	27%	37%
Female	1182	38%	33%	26%	32%
12yo	236	38%	30%	26%	31%
13yo	896	40%	34%	27%	33%
14yo	50	36%	34%	27%	32%

Table 3. Results from testing in Ireland (n=2464)

The following observations are apparent from the examination of the data to date:

- Spatial skills for students in the US improved slightly between Wave 1 (beginning of fall semester) and Wave 2 (beginning of spring semester). The average score increased from 31% correct to 36% correct between these two testing periods. This result implies that the spatial skills of students will increase slightly with time with no intervention. This finding is also apparent from examination of the data from Ireland where it appears that the spatial skill levels of the 14 year-old students is slightly higher than the spatial skill levels of the 12 year-old students.
- The MCT appears to be the most difficult of all the component tests given. This finding was obtained both in the US and in Ireland. For this age of students, the scores on the MCT are only slightly better than chance (20%). From the analysis in the US, it appears that the test reliability for this component, as measured by the Cronbach's Alpha is also very low. This could indicate that this test component is simply too difficult for students of this age and that reliable results may not be obtained through its use.
- Scores on the Modified Lappan test are also not significantly better than chance for the Wave 1 testing and are slightly better for Wave 2 testing. The reliability for this test is on par with the test reliability for the PSVT:R and the DAT.
- It is likely that the reliabilities for the individual component tests are low due to the small number of items. When all instruments are combined, the test reliability is in the acceptable range.
- Gender differences in the tests are apparent from examination of the data from Ireland. (It should be noted that the data from the US has not been disaggregated by gender as of the time of this submission but will be available in time for paper presentation.) It appears that the gender difference is largest for the PSVT:R which is as expected since gender difference on mental rotation tasks are particularly robust, as reported in the literature (Tartre, 1990; Linn & Petersen, 1985; Voyer, Voyer, & Bryden 1995). No gender differences for the MCT were obtain from the Irish data, possibly influenced by the low test reliability of that

component.

- The scores of the US students in wave 2 (comparable to the timeframe when Irish testing was accomplished) appear to be slightly higher than those of the Irish students, i.e., 39% versus 45% on the DAT and 35% versus 41% on the PSVT:R. This finding mirrors previous findings obtained with first-year engineering students between US and Irish students (Sorby et al, 2014).

5. Conclusions

The authors of this paper have embarked on a multi-year multi-national study of the impact of spatial skills training on the math achievements of secondary students. In the first year, we have accomplished baseline testing in the partner countries (Australian data will be gathered in time for paper presentation). Similarities in the test data between countries as well as differences have been noted and will be used to compare and contrast students from the various countries as this research project progresses. Since 3-D spatial skills are critical to success in engineering and since the 3-D spatial skills of women tend to lag behind those of their male counterparts, intervening to improve spatial skills could be a key to diversifying our engineering programs with respect to gender.

Acknowledgements

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Online Support System for Transnational Education

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Abstract: The number of students who travel abroad to study or are enrolled in a distance learning program outside their home country is growing. According to UNESCO, such students are called internationally mobile students (IMSs) and 5 destination countries accounted for almost 50% of IMSs: United States (18%), United Kingdom (11%), France (7%), Australia (6%), and Germany (5%). Internationalisation of the higher education has created the so-called borderless university, providing better opportunities for learning and increases the human and social sustainability.

In this paper, we propose an online system to support transnational education (TNE) in Australia. This system will consist of both an online module and quiz, and an automated assistance module. The first part will ensure that students understand TNE-related potential problems, such as the importance of submission deadlines, and provide students early hints and help to avoid the TNE-related problems. The second part will provide assistance with general issues related to studying and living in Australia, and more specific ones tailored to a specific institution. The ability to provide an immediate response when required will help overcome feelings of isolation, and provide appropriate advice on matters such as plagiarism and related issues, many of which arise from misunderstandings due to divergent cultural backgrounds and a lack of awareness about differences in socio-cultural environments.

Keywords: Transnational education; Learning; Teaching; Online support.

1. Introduction

According to UNESCO statistics[1], Australia is the 4th largest provider of international education. In 2012, approx. 250,000 mobile students (6% of total mobile students) were hosted in Australian universities. Internationalisation of the higher education has created the so-called ‘borderless university’ (Sadiki, 2001; Knight, 2015), which provides better opportunities for learning and increases human and social sustainability (Woodcraft, 2012; Vallance et al., 2011, Penzenstadler et al., 2012). This also means new challenges due to the diversity of cultural and legal requirements. One obstacle to successful transnational teaching and learning is the diversity of cultural, technical and educational backgrounds of both academics and students. The goal of our approach is to help students and academics to overcome this obstacle, and to possibly convert this obstacle into strength. Naturally the first step in developing a potential solution to this problem is to understand it in appropriate detail.

There are a number of case studies and analytical works on the potential and real issues within transnational education. For example, K. Gribble and C. Ziguras (2003) pointed in their work to general transnational education issues that teaching staff might have and suggested additional training for teachers. I. Dunn and M. Wallace (2006) presented a case study on the preparedness and

[1] http://www.uis.unesco.org/Education/Pages/international-student-flow-viz.aspx

experiences of the Australian academics and transnational teaching. Another study has shown that transnational teaching has the capacity to transform educators, especially if they particularly recognise the impact of cultural differences in the teaching and learning process (Hoare, 2013).

Most of the case studies and other works focus on teaching aspect of education. However, the education process consists of two highly cooperating parts: *teaching and learning*. Moreover, the number of students involved in the process is much higher than the number of teachers. For this reason we suggest studying the problem of diversity from the students' perspective, and hence to analyse potential solutions with this in mind.

RMIT University, like many Australian universities, currently provides a number of orientation events for new students, as well as a webpage with comprehensive information on the study at the university[2]. However, both options are passive experiences for the students, and there is no examination of whether the students are really familiar with the corresponding material. The current webpage also provides only a small amount of information related to the transnational aspects of education. For instance, the RMIT myCommunity is providing a few topics such as Tech Support and New Academic Street project discussion having a large number of unsolved posts and/or with no replies. Moreover, students with limited knowledge of English might find it difficult to follow the orientation session and to ask questions if something is unclear to them. In our recent work (Alharthi et al., 2015, Spichkova and Schmidt, 2015) we have presented an approach to requirements specification and analysis for eLearning systems and for geographically distributed software systems. Systems for eLearning are usually developed for use within different organisations or even different countries. It is not at all unusual to find that the specific requirements differ between organisations or countries for technical, cultural, or legal reasons. The challenge is to deal with this diversity in a systematic way, avoiding contradictions and non-compliance.

In our current work, we intend to extend our approach to systems requirements engineering to the development of a TNE support system, consisting of (1) an online module and quiz, and (2) an automated assistance module, cf. Figure 1. The system will provide an immediate response when required and appropriate advice on matters such as plagiarism and related issues, many of which arise from misunderstandings due to divergent cultural backgrounds and a lack of awareness about differences in socio-cultural environments.

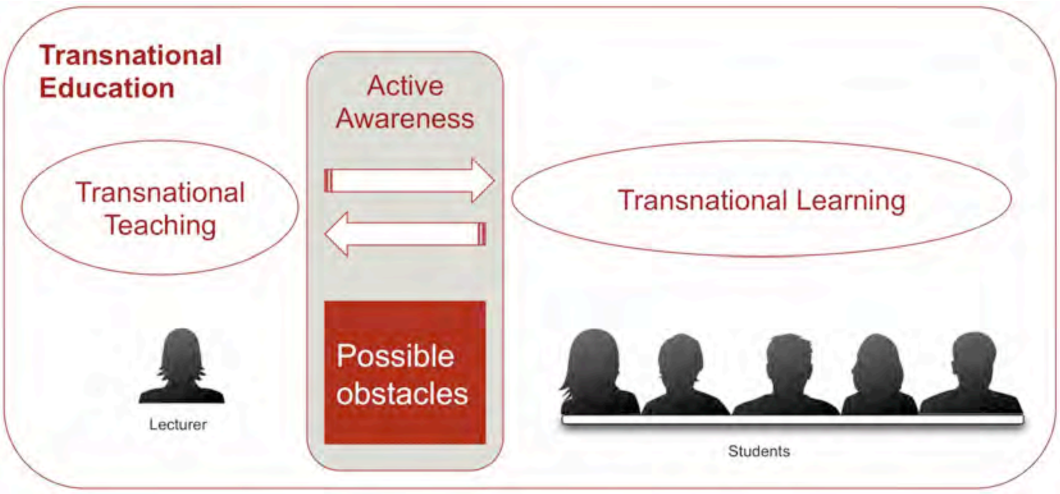

Figure 1. Transnational education: Transnational teaching + transnational learning

2 https://www.rmit.edu.au

2. TNE Online Support system

The general architecture of the proposed TNE online support system is in Figure 2. This system will consist of two core parts:

- An online module on TNE related topics with a corresponding quiz designed to ensure that students understand TNE-related potential problems, such as the importance of submission deadlines, and provide students early hints and help to avoid the TNE-related problems.
- An automated assistance module to provide assistance with general issues related to studying and living in Australia, and more specific ones tailored to a specific institution.

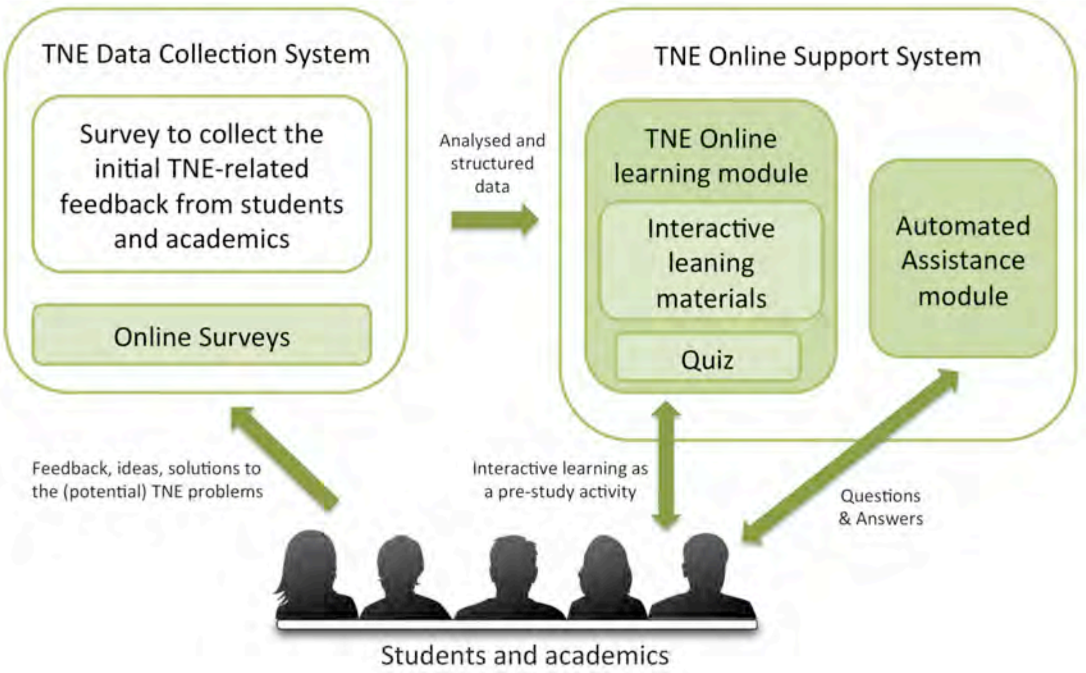

Figure 2. Proposed TNE Online Support System

2.1 Collection and analysis of the TNE data

The first step is to collect TNE-related feedback from the students and academics, including not only the descriptions of current issues but also gathering from students some appropriate suggestions and solutions. This step should be inclusive for two reasons:

- Students might suggest some effective and creative solutions, which haven't been previously taken into account by academics,
- Including students in the design of the solution will increase their engagement with the university, which will generally have a positive impact on their studies.

Additionally, the system will provide an online survey available at any time during the semester as well as on holidays. This would help to collect related feedback, suggestions and solutions more efficiently.

2.2 TNE online support system

The second step is to develop the online support system. RMIT University already has a number of online modules which are used for the induction and training of new staff members, on topics such as Health and Safety. We propose a *TNE Online Module*, which should be completed by both staff and students at the beginning of their study, as a final stage of the enrollment process. If the corresponding quiz is compulsory (but has no influence on grades), the teaching staff can have much greater confidence that the students are really familiar with the corresponding TNE material.

This learning module would

- Help students to understand TNE-related potential problems.
- Provide hints and assistance with TNE-related issues.

This solution would be especially beneficial for the students without strong skills in English, as it does not rely on listening skills. Also, this module may assist not only students but also the teaching staff; they will have a summary of the pre-study activity indicating appropriate students' level. Then, teachers can reconfigure programs to accommodate these differences. For instance, students who may interact in the second language, and have different culture-bound affecting communication skills.

The *automated assistance module* would then provide advice to the students on questions related to studying or living in Australia. Students are often hesitant to ask questions in 'live' sessions, due to communication or language issues. Students (even local students) are also hesitant to ask questions in front of other people, either in person or on electronic forums such as Blackboard discussion boards or Facebook. Often this leads to the question not being asked at all, or via more private means such as email. This creates a new problem, in that a staff member needs to reply to each individual query. Given that such queries often arrive in bursts around the same time, it will usually take up to one or two days for the student to receive a reply. In contrast, our proposed system will be available at all times and provide immediate answers.

We stress that our proposed system is intended as a replacement for many of the typical queries asked by students, but not as a complete replacement for human advisors. There will always be some issues or problems that will require human intervention, but the expertise of those able to do so will be put to greatest effect if many repetitive and routine queries can be dealt with by a system of this kind.

The system might be also provided in different languages using automated translator, to reduce the gap of communication between students having different mother tongues, as well provide a sustainable solution for information storage, to avoid duplicating storage of similar questions submitted in different languages.

There are also a number of contexts at RMIT University in which such a system could be used. The most natural starting point is with onshore international students here in Melbourne. However, as RMIT has two campuses in Vietnam, as well as a number of programs taught offshore, this system may provide benefits for a wide variety of TNE students.

Rapid changes in society and technology are affecting education and economic (Stepanyan et al., 2013), so it is important is to ensure consistent processes for transnational education and improve cost-effectiveness of the transnational education. The proposed system would help onshore international students and teaching staff not only to sustain TNE market but also to improve educational attainment. By guaranteeing of sharing knowledge, engaging international and local students, and developing students and teaching staff could minimise diversity and culture shock. For instance, the acknowledgement of different learning styles could improve student satisfaction.

3. Conclusions

In this position paper, we have presented our vision of a TNE online support system. This system will consist of both an online module and quiz, and an automated assistance module. The first part will ensure that students understand TNE-related potential problems, such as the importance of submission deadlines, and provide assistance with TNE-related issues. The second part will provide assistance with general issues related to studying and living in Australia, and more specific ones tailored to a specific institution.

The ability to provide an immediate response when required will help overcome feelings of isolation, and provide appropriate advice on matters such as plagiarism and related issues, many of which arise from misunderstandings due to divergent cultural backgrounds and a lack of awareness about differences in socio-cultural environments. We believe that this system will help students and teachers to overcome potential obstacles, which come from the diversity of their backgrounds, especially from the cultural diversity.

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Practice of Active Learning in the Computer Science Course

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Abstract: This study mentions the practical application of active learning in the computer science education. This paper outlines the process where the 30 weeks/year classes turning from those "mainly based on learners' individual studies" into those "mainly based on team project activities." An annual program is divided into three stages and in the first stage, passive learning is offered. In the second stage, on top of the study form offered in the first stage, the project-based activities are introduced to move onto more active learning. Furthermore in the third stage, the project-based activities are combined with the teamwork tasks and individual tasks so that the students could continue with more collaborative learning experience. A student is chosen in each of the student teams as a learning leader who assumed "the role of leading the team projects", so that the team-based activities are performed smoothly. By making the teams assess each other's products, those outcomes are deemed favorable on the whole. In some of the teams with the lowest assessment scores, it was revealed that the learning leader was not functioning effectively.

Keywords: computer education, active learning, PBL

1. Introduction

This study mentions the practical application of active learning in the computer science education. The case study was run at the Department of Global Information and Management of the Kanazawa Technical College (the "school"). In the computer science classes of this school, the students initially study the basic course that includes computer application skills and computer programming. Later during the applied stage, they are taught about web design, network management, operating systems (OS) etc. The classes are the combination of classroom teaching and practical training. However, the practical training tends to be more individual-task based.

The students are not merely to enjoy the knowledge bestowed upon them, but they have to develop the abilities to apply the knowledge to the next steps. Therefore in Japan, the current trend is to gradually replace the more conventional "classes of passive learners" with the more favorable "classes in which the learners can willingly participate", i.e. running active classes as discussed in the central education council, Japan (2012). The PBL teaching incorporating the team-based activities at universities is but one of many examples as shown by Takemata (2012), Hara et al (2015) and Mills et al (2003). Taking hints from this, in this study we decided to incorporate team-based activities in the classes, therefore changing the class components from individual-based works to team-based tasks. We also explored the class planning methods in which the students can keep learning collaboratively via working on the tasks given to them.

2. Method Subject on which the Study Focused

The unit on which this study focused was "Information System III" for the 5th year students of the school and it laid down the basics of the OS. We decided to make the students create their own OS so that they would understand how the OS worked. We designated the following as the unit textbook (the "textbook"): Hidemi Kawai, 30 Nichi De Dekiru! OS Jisaku Nyumon [In 30 Days! Beginner's DIY OS], (Mynavi Publishing, 2006). This textbook has an established reputation in Japan as the "self-study book on making a DIY OS" and it is further backed by the self-study support website provided by Tatsu-Zine Publishing, Inc. However, this textbook requires programming knowledge using the assembler language and the C-language as a prerequisite. To enable this, the classes (2 hours per week, for 30 weeks = 60 hours in total) were divided into the three stages as seen in Figure 1. In Stage 1, the assembler language programming was taught over 15 weeks. In Stage 2, the C-language programming was taught over 7 weeks. Furthermore, a team project to create courseware to learn about the C-language programming was also assigned. In Stage 3, the students studied the textbook on an individual basis. This was further supported by a team project designed to support the self-study of the textbook.

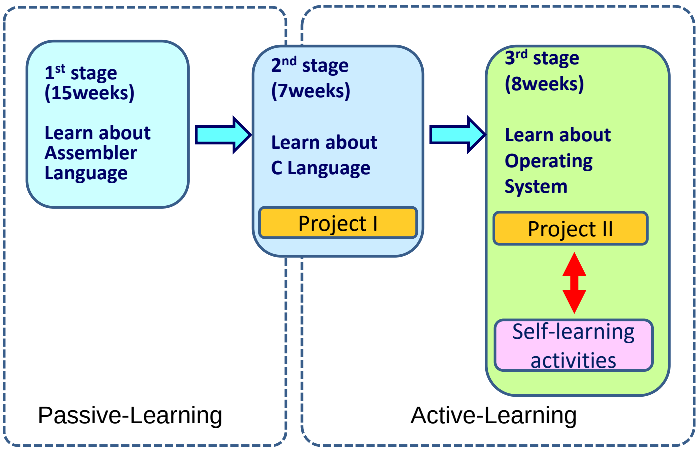


Figure 1 Outlines of the classes over 30 weeks

3. Transition from Passive Leaning to Active Learning

In Stage 1 of the three stages shown on Figure 1, the tutor would instruct the students on the assembler language while they learned the components through actual programming exercises. In this stage, the learning format was the one the students were relatively familiar with – a passive one.

During Stage 2, the study format was gradually changed from passive to active. The procedure in which the tutor instructed the students on the C-language reinforced by actual programming exercises remained the same as in the Stage 1. But this was enhanced by a project activity in which the students were divided into teams (35 students, 6 teams). The common concept for all 6 teams was "to design an e-Learning courseware for the self-study of the C-language programming." The project was assigned to raise the issue of how to design "courseware that is easy to learn from the students' point of view."

The Stage 3 assumes the active study format. The project activities were run in the order as shown on Table 1. The common main concept for all 6 teams was "to design things to support the study of the designated textbook." Upon this main concept, each student team came up with its own project theme. The students were also required to study the textbook individually in conjunction with the project activity. It was forecast that if some students did not do enough self-study the smooth operation of the team activities would be hindered. To prevent this, a student who could support every member's self-study and also lead the pace of self-study within the team was selected as the study leader. Every week, the tutor gave advice to the study leaders on the key points on how to read the section for the week from the textbook, so that each student's self-study would go smoothly supported by the study leaders. By doing this, we made all the students think what would help the learners in their self-study, and we thought this would eventually lead to the "problem-solving abilities as a team."

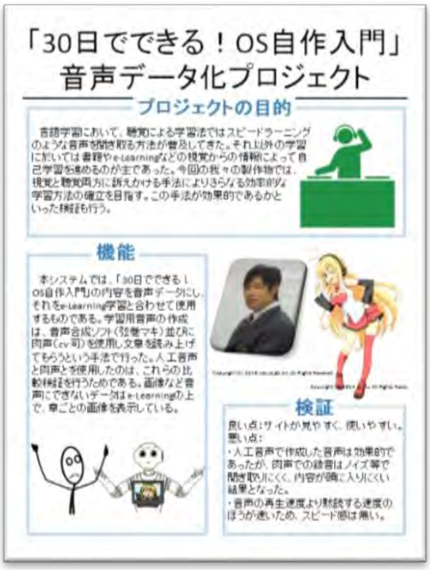
Table 1 Project timeline

Week	Activity content
1st Week	Selecting the project theme: list candidate ideas for the project theme based on the main theme; evaluate the ideas according to the assessment criteria (more than 5 required); select one that attracted the highest marks as the project theme.
2nd Week	Fine-tune the concrete ideas according to the project theme.
3rd Week	Come up with roughly 10 ideas that satisfy the design. Express the ideas in illustrations that demonstrate their intentions well.
4th Week	From the ideas, select the ones to be realized and make them more concrete.
5th Week	Evaluate the realized ideas and prove their effectiveness.
6th Week	Produce materials explaining the project activities (project outline papers).
7th Week	Produce materials (PowerPoint slides, posters etc.) explaining the project outcomes (i.e. the contents of realization).

Figure 2 shows the scene from the briefing session of the final results. Figure 3 shows some of the posters that were shown at the briefing session. During Stage 2, all the teams were also required to design e-learning courseware as part of the project activities. To stress the importance of experiencing the project activities, the project themes had already been decided for them. However in Stage 3, the teams were free to choose their own project themes to place importance on the formation of the students' own ideas. The teams came up with varied solutions such as video teaching materials, assistive materials for the classes, e-Learning courseware, the SNS site for study support.

Figure 2 Briefing session of the final results

Project Theme: Design of Materials which support self-study activities by using Easy-to-Understand Explanation



Project Theme: Design of Materials which support self-study activities by using Voice Guidance

Figure 3 Posters shown at the briefing session of the final results

4. Results Assessment of Team Projects during Stage 3

A study leader was selected from each team to ensure the parallel functioning of the project activities and the team members' individual studies, as well as the smooth running of the projects themselves. Figure 4 shows the results of the questionnaire that was given to the 29 out of the 35 students in total (minus the study leaders) regarding the projects run during Stage 3. Question 1 asked about the satisfaction rating of the projects' results and they seem to show that almost everyone was happy. Question 2 asked whether the student was able to contribute to the project as a member of the team, and 69% of the students replied positively. In Question 3, they were asked whether the existence of study leaders helped their own studies (if the study leaders were functioning effectively), and 62% replied positively. Question 4 was about the computer programming abilities of the study leaders and 72% of the students responded positively.

Q1: Are you satisfied with your team's product?

Q2: Were you able to lead the project to the positive direction by supporting the study leader?

Q3: Did the study leader support your studies?

Q4: Are you satisfied with the computer programming ability of the study leader?

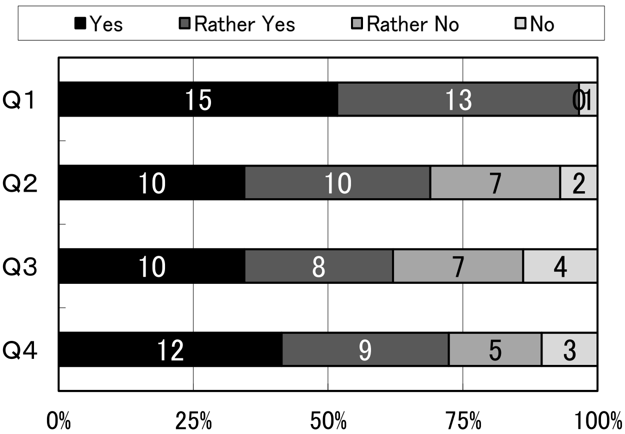


Figure 4 Questionnaire results regarding the study leaders for the project activities

Table 2 shows the results of the cross-team assessments of the projects' products (team peer evaluations). The 10 criteria were each evaluated with 5 grades. There were 6 teams, and each team can potentially obtain maximum 50 full points x 5 teams. The points shown on Table 2 are the values according to the conversion of full 250 points into 100. Teams 1, 4, 5 and 6 obtained over 70 points and their products are arguable assessed as gaining favorable opinions. On the other hand, Teams 2 and 3 received lower ratings than the other teams. From the tutor's observation, it had been known that the projects of these two teams were not running as smoothly as in the other teams. Therefore, question 3 as shown in Figure 4 (if the study leader had helped the respondent's studies) was reexamined. Of the 11 respondents who responded negatively, 7 belonged to these 2 groups. This value demonstrates that, of the 9 students of those two teams (11 students total minus the 2 study leaders), 7 students thought that "the study leaders were not functioning." In these 2 teams, it is evident that the team tasks and individual tasks were both processed without the functioning leaders. This may have made the members' self-study less than satisfactory, due to the fact that the tutor's advice for self-study was not communicated the teams. What the members learnt through self-study was reflected in their project activities, and in turn this was supposed to make the projects' products better. However, with these 2 teams, this did not happen, resulting in poor contents of the products compared to those by the other teams, hence the lower evaluation ratings.

Table 2 Assessment criteria for the products of the projects and the marks obtained by the teams

	Assessment criteria
1	Is the project theme proposed by this team appropriately suited to the main theme?
2	Does this team's product function as the solution to the project theme?
3	Did you feel like using the demonstrated product after hearing the team's final pitch?
4	Can this team's product be used on the computer, which you use normally (meaning if it does not force you to install new software)?
5	Does the content of this team's product cover the area of self-study (meaning if it covers the Weeks 1 to 7 of the textbook ("In 30 Days! Beginner's DIY OS")?
6	When studying with this team's products, does it provide learner with the troubleshooting measures when encountering the problems and questions over its contents (meaning if it has the help function)?
7	Do the illustrations employed in this team's products appropriately describe the products, and can the texts be easily understood by the learner?
8	When studying with this team's products, does it clearly say "what is meant to be studied with it" at the beginning (to maintain the motivation of the learner)?
9	Does this team's product come with the "operation manual"?
10	Is this team's product at the level that can be sold commercially (asking about the degree of perfection)?

Team Number	1	2	3	4	5	6	Total	Marks
1		42	38	39	39	29	187	75
2	29		32	32	36	26	151	60
3	24	45	31	31	31	29	160	64
4	29	48			36	33	189	76
5	33	45	32	32		28	182	73
6	36	48	32	32	38		191	76

5. Conclusion

Most students on this course are not studying OS in depth (in detail) but rather doing so because they need the basic knowledge of OS so that they can understand the manuals etc. while studying the information processing. In this study, we aimed for the class planning to make the students learn as deeply as possible about OS, while trying to maintain the interest levels of the students with this sort of requirement. The products of Stage 3 demonstrated the teams' characteristics (members' abilities, interest in information science, eagerness to study) and we think that they were able to lead these students out from the "field of passive learning" into the "field of active learning". To ensure the smoother running of the projects, a student was selected as a study leader for each team and assumed the role of leading the team project. However, when we made the teams assess each other's products, it became clear that the study leaders were not functioning in the teams that received lower ratings. This leaves us with the difficult issue of choosing a leader in a team project activity. We believe this can be eventually solved as the students become more experienced in project activities, and we would like to research the "project management within classes" with this point in mind in the future.

Acknowledgements

We would like to thank Dr. Daisuke Takagou and Dr. Takashi Kawanami of Kanazawa Institute of Technology (Department of Technology) who kindly advised us on our OS classes and recommended to us the use of 30 Nichi De Dekiru! OS Jisaku Nyumon, (2006) by Hidemi Kawai.

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Development of small size material testing machine for regeneration medicine

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Abstract: Treatment policy in injury such as rupture or fracture of the tendon is often determined from a doctor's experience. In recent years, there is a movement to try to establish the quantitative strength evaluating criteria. For obtaining the criteria, the quantitative mechanical material's testing evaluation for regeneration medicine is required. Especially, the small materials such as tendon and bone of rat are small, so it is difficult to accurately measure the bio-material. In this study, by developing the test methods and testing machine for performing appropriately strength test of the biological material, it is intended to lead for education and training of a doctor. Here, we produced a jig for carrying out 3 points bending test using bone of the mouse, and examined whether the strength of the bone can be measured accurately. Also, the finite element analysis was carried out in order to examine the bone's broken mechanism and the stress distribution was clarified. Based on these analytical results, the testing machine specification was determined. The testing machine was designed by CAD and the testing machine strength and performance were simulated by the finite element method (FEM simulation). As the development small testing machine has portability, the tendon's tensile test and the bone's 3 points bending test can be carried out easily at anywhere.

Keywords: bio-material, CAE, Material testing, Regeneration medicine

1. Introduction

In this study, it is intended to develop test method and testing machine for measuring material constants, which is important in order to learn the engineering features of the bio−material, such as Young's module in the field of biomedical engineering. As a result, it is possible to understand the mechanism of damage to the biological material, and lead to the study new therapeutic methods. In addition, by accurately measuring the Young's modulus, it is possible to provide mechanical criteria to treatment policy, and make a precise treatment policy at inexperienced doctor. Not only that, it is also possible to measure whether having alternative to what has adequate strength of bio-materials such as artificial bones.

Therefore, it performed 3 points bending test using bone of mouse and considered how to accurately measure the Young's modulus. Also, it revealed mechanism of destruction during the bending test of the bone by using finite element analysis (FEM). Using these results, it designed the testing machine which suitable for performing the strength test of the small biological materials.

2. Method

2.1 3 points bending test

In this study, it used existing universal testing machine to perform 3 points bending test. However, it was impossible to use a jig provided, because the dimension of the bone is the very small. Therefore, it fabricated jig which size is suitable for dimension of the bone. It performed 3 points bending test using this, and calculated the Young's modulus using the test results. In the calculation, it used the theoretical formula of bending.

Fig.1 Testing machine

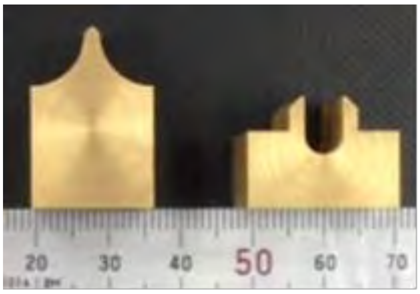

Fig.2 Fabricated jigs

After that, it compared the calculated Young's modulus and literature value, and considered the consistency with the test results.

$$I_z = \frac{\pi d^4}{64} \tag{1}$$

$$\mathrm{E} = \frac{PL^3}{48\delta I_z} \tag{2}$$

2.2 Finite element analysis

The simulation analysis by using FEM was performed for clarifying mechanism of destruction during the 3 points bending test of the bone. For this purpose, first it was taken CT images of bone before bending test. Then, the CT image was interpolated at the points and it reproduced the cross section by joining the point. Finally, the model of the bone was created by extruding the cross section to the desired length.

Fig.3 CT image and CAD model

The model' both ends are supported such as actual condition of 3 points bending test. In the analysis results, the considerable shear stress occurred with bending stress. So, obtaining the accuracy of the Young's modulus in the case of a comparatively short bone compared with the diameter, the evaluation of the material constant which considers the shearing stress is needed. The bending stress σ as shown in eq.(3) obtained from the analysis at the same force of experiment compared with the bending stress obtained from the simple bending moment and the modified coefficient for obtaining the accurate material's constant was found.

$$\sigma = \frac{M}{I_Z} y \tag{3}$$

3. Data Preparation

3.1 3 points bending test

It shows test conditions of 3 points bending test and test results.

Table 1 Test Conditions

Test Condition	
Type of test	3 point bending test
Load range	25N
Test speed	2mm/min

Table 2 Comparison of Young's modulus

	Young's modulus (GPa)
Experiment value	0.11
Literature value	1.0

The Young's modulus obtained by the experiment indicates very different values with literature values. As the cause, it is considered that the distance between the fulcrums is short with respect to the diameter of the bone. Actually, it is necessary to take about 20 times the distance between the fulcrums against the thick of the test piece. However, considering the length of the bone, the distance between the fulcrums of the jig is set to 5mm. Therefore, it is thought that the destruction occurred by not only the pure bend stress but the shearing stress.

3.2 Finite element analysis

3.2.1 Effect of the distance between the fulcrums

It was performed the simulation analysis by using finite element method to clarify the effect of shear stress on the destruction of bones. The analysis conditions are the same condition of the experimental 3 points bending test and the load subjected to concentrated force 0.5N on the midpoint as shown in Fig.4. Figure 5 shows the stress distribution obtained by the analysis. The comparison between the theoretical bending stress and the analytical value in the case of changing the fulcrums is shown in Fig.6.

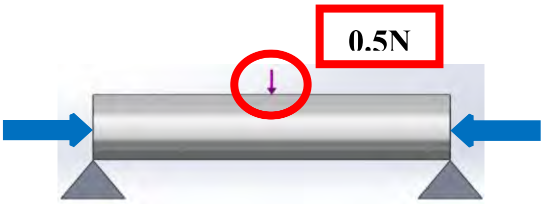

Fig.4 Fixing method of model

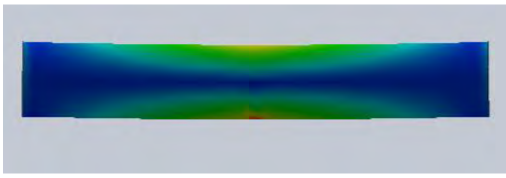

Fig.5 Stress distribution of bone model

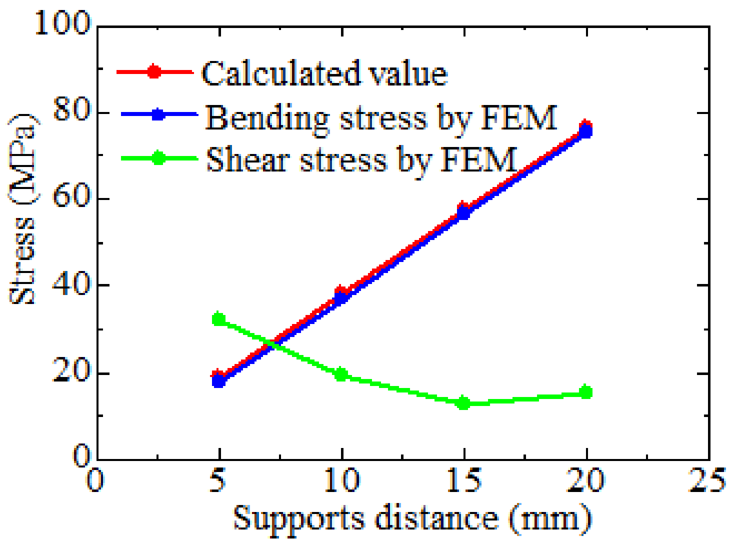

Fig.6 Comparison of the calculated value and analysis value

From this result, if the distance between the fulcrums is 5mm, it is found that shear stress had a large effect on destruction as compared with bending stress. Therefore, it was quantitative evaluated the effect of shear stress.

3.2.2 Analysis of bone model

As next analysis, the bone model analysis which was created from the bone of the CT image , was carried out. Table 3 shows the comparison between the bending stress calculated by theoretical bending formula and the analytical values, bending stress and shear stress.

Table 3 Comparison of analysis value and calculated value

	Calculated Bending stress (MPa)	Bending stress by FEM (MPa)	Shear stress by FEM (MPa)
WT1	4.32	4.20	34.13
WT2	2.50	2.60	28.68
WT3	2.47	2.25	38.60
WT4	3.29	3.05	33.16
WT5	3.01	2.85	25.20

As the calculated bending stress and the analysis bending stress are equal, this analysis is valid. Comparing the bending stress with the shear stress, the shearing stress shows about 10 times the bending stress.

4. Results

Using the analysis result, the Young's modulus of the bone was recalculated in 3 point bending test. It shows s nearly equal value with the literature value.

Table 4 Magnification and Young`s modulus

	Magnification	Young's modulus (GPa)
WT1	9.13	1.18
WT2	12.02	0.82
WT3	18.16	1.57
WT4	11.87	1.17
WT5	9.94	0.87

It was shown that the calculation of the short bone's accurate Young's modulus requires to multiply some coefficient, which the shearing stress obtained from FEM analysis was considered. However, WT3 showed a greater value than others. This is considered to be due to individual differences such as bone density. From this result, it is verified whether to recover or how much period is the complete cure by using this result in a new treatment method.

5. Conclusion

When it is carried out the bending test of bone of mouse, it was revealed the method of calculating the proper Young's modulus. So, a suitable testing machine for the strength test of micro bio-material is designed and manufactured. This testing machine has a concept that is small and light weight, and in lectures of biomedical engineering, it is the goal to be able to carry and use in various places. However, if the rigidity of the material is low to light, it can't be accurately measured. So, it is performing the mechanical analysis and considering the optimal material. It will make fabrication of testing machine and perform the verification test to be able to accurately measure.
Also, it is low reproducibility during modelling from CT image, it will consider the more reproducible method and perform analysis again.

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Experiential learning approaches for developing professional skills in postgraduate engineering students

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Abstract: The postgraduate coursework curriculum at the University of Southern Queensland includes a number of engineering management courses focused on developing professional engineering knowledge and skills, such as advanced project management, asset management, risk management and innovation management. Such skills are normally developed through traditional coursework approaches like on-line and written study materials, lectures and tutorials. While such teaching approaches have been successful, it is considered desirable to more strongly embed the professional skills taught into the learner's future professional practice. Teaching techniques based on experiential learning have the potential to achieve this objective, through processes based on activities like having a concrete experience, reflective observation, abstract conceptualisation and active experimentation. In teaching professional skills, this approach can be delivered through activities like reflective exercises designed to aid understanding, and assignments that as well as being authentic include reflection, development and implementation of the principles taught. It is also possible to further enhance student development though using marker feedback from an experiential learning activity, such as an assignment in a particular course, to inform a subsequent learning cycle of that course. Experiential learning can be enhanced through other approaches like embodied learning, which helps learners to better understand a principle through experiencing the application of theory, and through other techniques like gaming. Advantages and disadvantages of how experiential learning approaches can be applied to improve the development of professional knowledge and skills in postgraduate students undertaking engineering management courses, along with examples of its use, are discussed.

Keywords: Experiential learning, engineering education, postgraduate, professional skills

1. Introduction

In order to undertake practice, engineering graduates are required to demonstrate a set of professional skills that require them to be both knowledgeable in their discipline and have the personal and inter-personal skills that enable them to work successfully as part of the engineering team.

To provide engineering students with these skills, the University of Southern Queensland offers undergraduate programs to enable them to qualify as graduates, and postgraduate programs to further develop their knowledge and skills. The postgraduate coursework programs include the Master of Engineering Science and Master of Engineering Practice, which are designed to enable engineering technologists to meet professional engineering requirements, as well as programs for qualified professional engineers like the Master of Advanced Engineering. The University also offers research programs at Master and Doctorate level, including the Doctor of Professional Engineering, which has a one-third coursework component, and the Doctor of Philosophy.

The courses offered in these programs include both technical engineering courses and engineering management courses, and are focused on developing specific sets of professional knowledge and skills. There are a number of courses, particularly in engineering management, that are common to several of these programs. All of these programs contain a research component.

Course topics offered include asset management, advanced engineering project management, management of technological risk, technological innovation and development and assessment of future specialist technology. All of these courses are delivered on-line through distance education, and several are also delivered to classes at the Toowoomba campus of the University. The skills taught in these courses have been traditionally taught through standard educational approaches, such as the use of written study materials supplemented by lectures and tutorials, which are also made available to distance education learners. As a result of an ongoing continual improvement approach to the delivery of these courses, and the desirability of embedding the concepts taught in them to learners, there is an increasing emphasis on improved approaches to teaching and assessment, such as student centred learning, authentic assessment and experiential learning.

Experiential learning, which can be considered in its simplest form as learning by doing or experiencing, can be described through the experiential learning cycle developed by Kolb (1984) of a concrete experience, reflective observation, abstract conceptualisation and active experimentation. This paper further discusses the use of experiential learning approaches to developing professional skills in postgraduate engineering students through outlining professional skills required of engineers, the role of experiential learning in effectively teaching these skills, examples of the use of this approach, reflections on the resulting teaching and learning process, and a discussion and conclusion.

2. Professional skills requirements of engineers

Professional skills may be defined as the skills required for graduates to succeed in professional practice. Such skills require graduates to be knowledgeable and skilled in their discipline, and include both comprehensive knowledge and skills relating to their discipline and the ability to apply their knowledge and skills in the workplace. As well as including skills specific to a discipline, such skills include both generic (or transferable) skills; and also other attributes like motivation, self-confidence, self-management and self-promotion; and the ability to understand ethical conduct, meet deadlines, be punctual, relate well to others and show initiative (Crebert et al, 2011).

Professional engineers are required to achieve professional skills at two Engineers Australia levels. The first level is at the Stage 1 competencies that qualify students as graduate engineers (Engineers Australia, 2013), and the second is the Chartered Professional Engineer level, which may be achieved after the graduate has completed sufficient professional engineering experience (a minimum of three years), and can demonstrate competencies in personal commitment, obligation to community, value in the workplace and technical proficiency (Engineers Australia, 2012). In addition, all practising engineers are required to comply with a Code of Ethics that defines the values and principles that shape the decisions that engineers make in professional practice (Engineers Australia, 2010).

The professional skills of engineers at graduate level are achieved through a combination of activities like theoretical study, and experiential tasks like work experience, laboratory practice and undertaking research projects. On the other hand, many of the competencies expected of more experienced engineers will be obtained through application of professional knowledge and skills. Postgraduate study can aid this process, particularly if it builds in a systematic way on the learner’s professional experience. Both sets of requirements underscore the importance of at having least some courses with an experiential learning approach in formal engineering education at both the undergraduate and postgraduate level.

3. The role of experiential learning in teaching professional skills in engineers

Experiential learning, or learning by experience has been developed by Kolb (1984) and other authors. The Kolb model consists of the stages of concrete experience (feeling), reflective observation (watching), abstract conceptualisation (thinking) and active experimentation (doing) phases. Successive Kolb loops can be viewed as a spiral of continual development and improvement.

The experiential learning model has been extended into other applications. For example, Zwetsloot (2003) has applied experiential learning to the development of corporate social responsibility at the organisational level through a continuous improvement and innovation model, applied to a process of doing things right the first time and doing the right things. This model is used in the context of learning from experience, or experiential learning, which can be specific training, education, or the supply of information.

Experiential learning, with its development of competencies through successive cycles of feeling, watching, thinking and doing, is traditionally well suited to the development of traditional engineering skills through activities like using guest speakers, work placements, simulated projects and role plays (Experiential Learning in Planning Education, 2015). An experiential learning approach can also be used, in conjunction with good learning and teaching processes, in teaching courses like engineering asset management, which combine sound theory with good engineering and business practice.

An example of good learning and teaching practice is student centred learning, which according to Biggs (2001) focuses on teaching that leads to learning and leads to high quality learning. It is underpinned by the principles of good assessment, which certifies and prompts learning (Boud, 1998). To fit with an experiential learning model, such assessment should meet the principles of constructive alignment and be criterion focused (Gulikers et al, 2004). It should therefore challenge learners and be relevant to their course of study.

One option for good assessment with respect to the development of professional skills is authentic assessment, which accordingly to Gulikers et al (2004) is a form of performance assessment and accordingly links closely with criterion-referenced assessment. It is noted by these authors that to positively influence student learning, authentic assessment should be aligned to academic instruction. It should also require learners to demonstrate their competencies in a setting that resembles professional practice. Authentic assessment is divided by the authors into five dimensions (task, physical context, social context, assessment form and criteria). A sixth dimension, professional issues, was added by Thorpe (2013), who applied this approach to assessment in postgraduate engineering management courses, and in doing so was able to increase its scope.

Another approach that is related to experiential learning is embodied learning, or the development of relationship between the learner and the topic being studied. A description of it is “learning that joins body and mind in a physical and mental act of knowledge construction” (Nguyen and Larson, 2015), a position that is supported by the educational pioneer Dewey (1916), as cited in Nguyen and Larson (2015), who stated that senses are avenues of knowledge not because external facts are somehow ‘conveyed’ to the brain, but because they are used in doing something with a purpose,

Embodied learning can be considered to have three conceptual elements - bodily and spatial awareness of sensation and movement, unification of mind/body in learning, and the body’s role as sociocultural context. Examples of its application include interdisciplinary collaboration, problem-posing instruction, and thoughtful learning space design (Nguyen and Larson, 2015). Embodied learning approaches can be linked with good experiential learning. For example, Kolb and Kolb

(2009), observe the importance of team learning, problem solving and learning space design in discussing the application of experiential learning to management learning, education and development. Extensions to embodied learning include computer simulation and games.

4. Examples of the use of experiential learning in developing professional skills

It has been shown that experiential learning has a range of applications in developing professional skills in engineers, particularly when combined with approaches like student centred learning, authentic assessment and embodied learning and its extensions, such as gaming.

While the traditional applications of experiential learning include problem based learning, professional practice, work experience and similar activities, it has been shown above that it can have much wider application. For example, it can be used in areas like developing corporate social responsibility through a continuous improvement and innovation approach (Zwetsloot, 2003). Similarly, an experiential learning approach can be used for developing professional skills in postgraduate students, particularly in engineering management and research. The extent to which such development occurs varies with the course delivered and its objectives. To illustrate the application of experiential learning approaches in developing professional skills, the following three course groups are briefly reviewed:

- Postgraduate engineering management courses with one or more assignments and an examination
- Postgraduate engineering management courses with multiple assignments
- Research projects.

4.1 Postgraduate engineering management courses with one or more assignments and an examination

This group of courses is written from the point of view of developing professional skills in selected engineering management areas, such as asset management and risk management. Courses in this group have one or more assignments, followed by a written examination at the end of the semester. Asset Management in an Engineering Environment (University of Southern Queensland, 2016a), which has one assignment and an examination, is typical of such courses. This course is divided into two main sections – asset management concepts and applications of the concepts.

As this course was written with the professional engineer in mind as a learner, it draws heavily on asset management practice. As part of this process, it illustrates its teaching by reflective examples that draw on the learner's experience and research. The assignment is divided into two components – developing a strategic management solution to restore to good practice an asset management network with a number of engineering management issues that require addressing by the student acting as an asset manager; and an engineering economics exercise, which is based on a likely engineering asset decision making scenario. While this second question is reasonably well defined, the first question on strategic asset management specifies the parameters of the problem to be solved, but leaves it open to the learner to construct the particular asset network being reviewed, using personal engineering experience or research. While the examination draws on the course study material, it achieves a measure of experiential approaches and authenticity through requiring candidates, in a number of questions, to illustrate their answer with an engineering example.

4.2 Postgraduate engineering management courses with multiple assignments

Some postgraduate engineering management courses offered at the University are assessed by two or more linked assignments. In such courses, assignments occurring later in the course tend to build on the assignments that precede them. An example of such courses is Advanced Engineering Project Management (University of Southern Queensland, 2016b), the assessment for which consists of two assignments. This course teaches the concepts, processes and tools of advanced engineering project management through exploring the project life cycle, project management knowledge areas, professional issues in project management including the management of project sustainability, program management and current and future issues in engineering project management. It is supported by the Guide to the Project Management Body of Knowledge (PMBOK Guide), fifth edition (Project Management Institute, 2013).

This course also was written with the practising professional engineer in mind as a learner, and to further develop this learner adopts a strategic view of project management. It uses reflective, practical examples to illustrate its teaching. While each assignment has a minor question on specific aspects of the course, the main question in the first assignment challenges the learner, as a project manager who has just taken over a project with a number of issues to develop a process for it to be completed on time and to the required quality, and to report on the result to the project sponsor. In the second assignment, the learner is similarly required to address issues with three projects being managed at the higher level position of program manager, and similarly provide a report to senior management. This task allows the learner to utilise learnings from developing and receiving marking feedback from the first assignment in a similar, but more complex and higher level task in the second assignment.

4.3 Research projects

All postgraduate engineering programs at the University have a research component. The extent of this research component varies with the program in which it is undertaken, and can be a relatively small proportion of the course in programs like the Master of Engineering Science to the whole study program in the case of the Doctor of Philosophy.

The postgraduate research journey will usually commence with the submission of a research proposal. On its acceptance, the research process will move into the literature review, research methodology development, confirmation of candidature, conducting the research, analysing results of the research, developing conclusions and writing a research dissertation. This journey can be challenging, and can be subject to tight time pressures and regular progress reporting. Success in this journey usually comes after a period of considerable thought, experimentation, obtaining results, reflection, learning, further trials, and resultant modification of the research until final outcomes are achieved. This process is similar to the experiential learning process of Kolb (1984) and the continuous improvement approach discussed by Zwetsloot (2003). In undertaking this process, many researchers become closely linked to their research topic, resulting in a synergy between research and research topic that impacts on their thinking processes and brings their personal approach to the research, resulting an embodied learning experience.

5. Reflections on the teaching and learning processes

While a course like Asset Management in an Engineering Environment (University of Southern Queensland, 2016a) could be considered to have a typical course and assessment structure, it aims to focus on student centred learning where possible, uses assessment procedures that draw on real practice as much as possible, and allows learners to impart their professional engineering experience to assessment responses. While it does not strongly use the cycle developed by Kolb (1984), it has a number of components of experiential learning, including utilising as much as possible the learner’s existing expertise to further develop the learner’s knowledge, skills and interest.

In Advanced Engineering Project Management (University of Southern Queensland, 2061b), the process of building the main question on the second assignment on the feedback of the first, simpler assignment question of a similar nature allows the learner the opportunity to have the concrete experience of developing the assignment and receiving feedback from it, reflect on the results, think about applying learnings from the first assignment to the second assignment and write the second assignment using them. This process, which has been extended to a third cycle in a course assessing future technology, strongly utilises the experiential learning cycle developed by Kolb (1984).

Postgraduate research has the potential to link all the elements of experiential learning. The research journey is very much based on what the learner wants, is normally quite challenging, will be assessed from the point of view of its authenticity, and very much uses repeated cycles of the experiential learning process of Kolb (1984). It can also be argued that the postgraduate research journey contains the elements of embodied learning, as its consistent and challenging nature links the researcher with the research in a way that develops a synergy between them.

Anonymous student comments submitted to the University's survey of students at the end of each teaching semester for the 2015 offers of the two engineering management courses discussed above, which are shown in Table 1, support the experiential, practical nature of the two coursework oriented courses discussed. The research programs were not subject to student comments.

Table 1 Examples of anonymous student comments

Abbreviated title of course offer	Short description of comment type	Anonymous Comment
Asset Management in an Engineering Environment, External	Best aspects of the course Anything else about the course	Increasing my management skills and knowledge. I found it interesting, and think it will come in handy in my future career.
Asset Management in an Engineering Environment, On-Campus	Best aspects of the course	Knowing the concepts and reality of engineering asset management. It's really a useful subject.
Advanced Engineering Project Management, External	Best aspects of the course	It's practical and the assessment gives an opportunity to apply theory to real life situations.
Advanced Engineering Project Management, On-campus	Best aspects of the course	Everything is good.

In this table, the external course offer is typically undertaken by experienced practising personnel. Their views that the courses are practical and useful can therefore be considered positive from the point of view of development of their professional skills through studying them.

6. Discussion and conclusion

Practising engineers are required to possess skills that enable them to function in their professional life, including specialised technical skills, engineering management skills and transferable skills. At the postgraduate teaching level, the main skill sets to be taught are those that prepare them to be fully functional and independent professionals. While these skills are normally acquired through professional experience, their acquisition can be assisted by specialised academic study. A number of the courses taught in these programs, and in particular those focusing on the more practice oriented functions like engineering management, can be taught through advanced practices like experiential learning, which can be enhanced by other learning and teaching practices like student centred learning and authentic assessment. A similar argument can be mounted for technologists desiring to upgrade their qualifications to qualified professional engineer.

The use of experiential learning approaches in postgraduate study offered by the University of Southern Queensland, has been discussed, using the examples of two different engineering management courses and postgraduate research. One of the courses reviewed is offered with one assignment and an examination, and the second is offered with two assignments, of which the second assignment builds on the development of and feedback from the first assignment. The discussions of these courses are supported by student feedback on delivery of the courses. Postgraduate research has been discussed as an example of how a range of good teaching practices, including experiential learning, can aid the research process and facilitate embodied learning in the form of the researcher and the research study developing a synergy following a series of experiential cycles.

Overall, the application of experiential learning approaches, particularly in conjunction with other good learning practices, has been considered to be positive. Such learning also has the potential to be further developed by approaches like gaming. While gaming approaches and other extensions to experiential learning have not been discussed in detail, they have the potential to add to the realism of learning experiences, and to the potential for research activities to better link with the researcher.

While experiential learning can be positive for many courses, and has wide application in reinforcing theoretical engineering courses by activities like laboratory experiments and site visits, and in aiding the development and assimilation of work experience, it is unlikely to be suitable for all professional engineering development. For example, it may not be suited to courses with a high theoretical content. At the same time, it is considered a quite useful approach in professional development courses and in areas like research work, which have a clear cycle of experiencing, observation, thinking and experimentation.

One outcome of the discussion of the applications of experiential learning and related learning and teaching practices to the development of professional skills in postgraduate engineering students was the necessity to design the experiential component of the course to meet the purpose and objectives of the course. Thus, for some courses site visits, laboratory experiments, or gaming might be the best approach to utilising the experiential aspects of the course. A course aimed at developing professional skills in experienced engineers may be better suited to the approaches discussed in this paper. Research projects may require individual approaches to achieving the best outcomes. For these reasons, success in courses using experiential learning is only likely to be achieved through carefully considering and tailoring their experiential learning component to the requirements of learners.

It is concluded that experiential learning has considerable potential to be used in the development of professional skills in postgraduate engineering students, provided that its application is carefully considered and focused on the requirements of the course and its learners. The examples discussed indicate that there are a wide range of approaches to achieve this goal, both in the traditional experiential sense of practical activities, and in structuring professional development and other courses to achieve good outcomes through combining experiential learning approaches with other good teaching practices. Therefore, caution and careful course design practice are required to achieve positive learning outcomes through this approach.

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Traditional vs Non-traditional Teaching and Learning Strategies – the case of E-learning!

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Abstract: The traditional teaching approaches are generally teacher-directed where students are taught in a manner conducive to sitting and listening. It is true that traditional philosophies often allow us to continue with the lecture-based model with some useful results. However it is often argued that the traditional approach may not provide students with valuable skills. The teaching of mathematics that is usually referred to or called non-traditional uses constructivist philosophy as its basis; this implicates strategies in which an individual is making sense of his or her universe. So the student is an active participant, which may help develop, construct or rediscover knowledge – a major goal that can be a time consuming process if taken literally for each student; alternately, there is also a philosophical position known as social constructivism suggests group work, using a specialist language of the field, and discourse learning its cultural framework; social intercourse and problem solving being the most important part of learning process. It is argued that the non-traditional teaching is done using a problem solving or inquiry based approach; where the learner is the problem solver. Therefore, e-learning is considered to be more in line with the non-traditional approaches than the traditional. This paper critically reviews the literature on mathematics and engineering learning in terms of these approaches and compares them. The paper specifically examines the advantages/disadvantages of the approaches as well the manner in which they influence performance of students in mathematics and engineering courses.

Keywords: Traditional, Non-traditional, E-learning, Higher Education, Science Technology Engineering and Mathematics (STEM)

1. Introduction

This paper is as much a reflection upon more than 20 years of in class teaching of students in both high school and tertiary in several countries, as an in depth and critical examination of recent research on mathematics teaching with a focus on higher education in STEM subjects; in light of the advancements in technology thus far (Science, Technology, Engineering and Mathematics) (Tularam & Keeler, 2006; Tularam and Ilahee, 2007, 2008; Tularam, 2011, 2013ab, 2010, 2015). In the past thirty years in particular, there has be a concerted effort to develop students' conceptual understandings of mathematics often at the expense of practice, memory, and negatively labelled instrumental learning. The case of demonizing any teaching related to rote learning, instrumental or procedural understanding has been espoused (see, Abdulwahed et al, 2012; Kelson & Tularam, 1998ab; Tularam, 1997, 1998, 2015). The past thirty years have seen many changes in the system of delivery in education worldwide. In most cases, the methodologies tend to be derived from mainly the following constructivist authors: Piaget's cognition, Vygotksy's socio-cultural and von-Glaserfield (Piaget among others) constructivism. It is said that the traditional teaching method is not consistent with the above and therefore a number of new methods have been devised over time (Abdulwahed et al, 2012). The new technology has also enabled such philosophies to persist in classrooms of today but there are a number of disadvantages as well as advantages and these are to be highlighted in this paper. The main aim of this paper is to compare the traditional and e-learning approaches and further to examine whether the shift towards teaching mathematics has moved too far from the centre in the use of technology as means of achieving the best for mathematics and engineering students. Have we learned from past mistakes of history given the current situation of such low levels in both mathematics and science in Australia? Have we appropriately critiqued the theoretical positions espoused (even that of constructivism) in relation to the mathematics taught in engineering and sciences more generally.

2. E-learning and background to traditional teaching

There are a number of definitions of e-learning (also called elearning or eLearning) but Stockley's (2003) definition appears appropriate for mathematics education. "Elearning involves the delivery of a learning, training or education program by electronic means. E-learning involves the use of a computer or electronic device (e.g. a mobile phone) in some way to provide training, educational or learning material." (http://www.derekstockley.com.au/elearning-definition.html) Clearly, the actual procedures used in E-learning environments can be varied such as online training or education, Internet or an Intranet, CD's and DVD's and so on. It seems that distance education was one of the first areas that used e-learning in its delivery. Interestingly, the learning of e-learning is considered "on demand" thus overcomes many of the issues that plague the modern tertiary student attending lectures on time, avoiding parking at universities and other difficulties faced in travelling to places of learning for example. A combination of various methods, including traditional based online 24/7 lectures and tutorials can also be included e-learning but this type of combined effort is usually referred to as blended learning.

In brief, a computer that allows students to interact online and in real time may be referred to as an e-learning environment. A two or three dimension figure can be very useful in demonstrating geometrical work and graphing in mathematics and engineering. The algebra manipulations may also be presented in a more colourful and perhaps meaning ways using computer software such as Matlab and Mathematica etc. While not being concrete objects (of real life), it is in fact possible to represent pictorial and 3d graphs that do help bring mathematics to real life all be it in two dimensions mostly (Hollebrands & Lee, 2012). There are many examples of such e-learning environments in mathematical (e.g., The Geometer's Sketchpad, GeoGebra, Cabri); and statistical environments (e.g., Fathom, TinkerPlots). In such programs students may be able to manipulate objects etc. although not physical real life objects (Hollebrands & Lee, 2012). The software programs are designed to help students understand relationships, develop deductive and logical arguments using many examples for practice. It is argued that the programs may help reinforce mathematical interconnections with exercises that provide almost instantaneous feedback. The pictures and objects tend to concretize mathematical concepts so that the learner can explore mathematical relations between variables (Baccaglini-Frank & Mariotti, 2010; Hennessy & Deaney, 2008). Some research shows that students do from deeper and a more interconnected mathematical understanding in e-learning environments (Dick & Hollebrands 2011; Duval, 2006).

To examine the success of such environments there are mainly early school studies and some high school studies, but very few tertiary based studies. In most cases in such studies the students are asked to complete problem solving tasks and they are observed for their behaviour both physically and cognitively through interviews and success - measured by their ability to perform successfully the required task. The author has done much work in this area and examined problem solving in algebraic and mathematical problem solving studies over a period of more than 20 years (Tularam, 1997, 1998, 2013, 2014, 2015). In fact, there is a related study that is presently in press, which has investigated trajectories of students during their solution process when asked to complete tasks. Each student trajectories of problem solving were examined and the author noted that student access to technology in general may not assist their mathematical problem solving and may at times hinder it even further (unpublished paper). Student often copy and paste the solutions to assignment problems similar to those found from the internet without any level of understanding. This was noted when students were asked to explain their solutions.

The e-learning environment is a new concept of teaching and learning with the aim to increase the effectiveness of teaching. However, Colace et al (2014, p. 9) argued that the aim is to increase the quality and effectiveness but that of the "traditional teaching" itself rather than aiming for another totally different method. Clearly, this has different implications and may indeed be in line with the present thinking as will be noted later. The purpose of this paper also falls into the general aim of Colace et al's work. They wanted to know whether an e-learning classroom environment is an effective learning environment for children when compared with a traditional learning environment. The change has been occurring mainly due to the advancements in technology that has in fact improved the nature of e-learning processes immensely but for which audience – for the self-directed or highly motivated or more generally. The environment that creates and engages students and also has a sound and meaningful academic basis will in the end aid planning and decision making: thus will drive the future of mathematics and science teaching.

(1)

3. Comparison of traditional teaching and e-learning

An older study by Harrington (1999) found that traditional face-to-face course did well overall, but the student GPA was the major predictor of success. The findings showed three main differences in that the online students were mainly female, older with more experience than the face-to-face instruction group. The online completions had a greater college credit hours than face-to-face completions ($F=3.76$, $df=3/97$, $p<.01$). The face-to-face withdrawers had earned substantially fewer credit hours than online withdrawers. In both delivery types, the course completers who failed had significantly lower cumulative GPAs than either successful completers or withdrawers.

Academic advising or personal contact with the instructor was important, particularly for who marginal students. Benard et al (2004) stated that background variables significantly contributed to the academic performance for both online and face-to-face students. Inactive decision making meant that students set themselves up for failure by simply not being prepared enough for the courses chosen but those who did the work were not prejudiced by methodology. Also there was no difference in withdrawal or failure rates. Zang (2005) examined the effectiveness of computer-assisted instruction (CAI) versus traditional lecture-type instruction on triangles (younger students). The students in the control groups were taught the concepts of triangles in their traditional classes, while the students in experimental groups were instructed in a computer lab. No statistically significant difference was found between the students' achievement. Shallcross and Harrison (2007) examined Chemistry lectures from years 1-4 for differences between three delivery methods - Category 1: used only electronic media to deliver courses, Category 2: used a mixture of electronic and non-electronic; and Category 3: which used non-electronic only. The students and lecturers both preferred non-electronic methods but no significant differences were noted amongst the methods. However, students felt that the material covered a lot of work and student needed hard copies of the notes for learning. Some felt the diagrams used were rather complicated and at times seemingly irrelevant images were being used. Also, the online lectures were presented quickly.

Spradlin (2009) using analysis of covariance showed no significant difference in scores of students receiving traditional mathematics lecturing and traditional with computer-assisted instruction. However, a significant difference was found in the scores of females and males, with females outperforming males in both modes of instruction. Descamps et al (2006) examined the role of e-learning technologies including the potential that on-line content can bring to education but they argued that this was not realized in mathematics. The materials presented are mainly formulae with some concrete and pictorial representations and interactivity is difficult on-line.

Seppala et al (2006) argued that on-line instruction is a viable alternative to traditional instruction by improving learning and reducing costs. While there were some positive results, a number of disadvantages were also noted: different learning styles, collaborative learning and discussion type instruction was not catered for online etc. It is possible that technological tools may be the answer to students' mathematical difficulties yet studies their studies show that e-learning did not help as much for the those with weak mathematical skills and moreover, e-learning does not help much in problem solving either. Further, those with weak technology knowledge or some negativity towards technology may indeed be further frustrated and in the end not acquire the necessary conceptual understanding. Caprotti et al (2006) noted that students embraced any synchronous and asynchronous on-line learning at the university level in that on-line instruction method was a viable alternative to traditional instruction.

Smith and Ferguson (2006) studied student attrition in mathematics e-learning with data showing that e-learning in mathematics does not work as well. Student attrition was used as a measure of student satisfaction and course viability with attrition in e-learning and comparing attrition in face to face courses. E-learning recorded higher attrition with significantly higher for math courses than other non-mathematics courses. In the case of face to face courses, there were no differences in attrition rates for math versus non-mathematics. It was hypothesised that the online student populations were different from the face to face group. Some studies have noted that females are more likely to undertake online classes and they tend to gain better higher grades than males; and generally do better in the online environment (McCann, 2006; Friday, Friday-Stroud, Green, & Hill, 2006).

Smith et al. (2008) studied discipline specific e-learning that has been largely not studied when investigating the effectiveness of the e-learning course design. This study investigated how instructors of mathematics viewed e-learning when compared to other disciplines: whether e-learning met the challenges of their discipline. They found that significantly less mathematics instructors were likely to view the existing e-learning models and management systems of the time as appropriate for their discipline.Wilson and Allen (2011) also found a marked difference in the success of students taking online courses versus students taking face-to-face courses. The online students had a higher withdrawal rate, failure rate and had difficulty completing assignments on time. The students are more likely to withdraw from online courses than traditional lecture based courses (McClaren, 2004; Lawrence & Singhania, 2004). But when courses are redesigned Temple (2013) noted fewer student withdrawals.

Aral and Caraltepe (2012) questioned "Does considering learning styles improve e-Learning performance?" Allowing for different learning styles indeed helps students' understanding of mathematics but there are not an adequate number of studies on either traditional learning or e-Learning to enable reliable deductions. A small number of studies show positive outcomes but much less work has been done in the tertiary sector. Clearly, adaptive teaching methods based on learning style would tend to improve mathematics performance (Tularam & Hulsman, 2013: 2015; Temple, 2013).

Tawil et al (2012) studied students' perception towards the importance and usefulness of modern technologies such as e-learning (WILEY PLUS) in comparison with the more traditional lecture. The sample included tertiary students who have taken mathematics and statistics. This study reveals that there is a significant difference between WILEY PLUS and lecturing. Overall, traditional lecturing was favourable in the learning process for both courses. It was the explanations, notes and assignments provided by lecturer that assisted their understanding of topics. So and Ching (2012) stated that "lessons are more interesting when blended using technological resources" (p. 10). They found student academic achievements were slightly higher in the electronic learning environment when compared with the traditional method. The e-learning approach included differentiated lessons made suitable for students at different levels. The parents were also involved in the study for they helped with homework with work continuing at home. Albano et al (2013) studied online learning in professional development of mathematics teachers. The e-learning survey results showed that e-learning needs to be well planned: tools and activities should be well designed in full detail and the scope. The focus and use of activities ought to be well stated in order to avoid "simply" participation. Thus blended learning should be fully involved using the relevant communication tools and collaborative activities if there is to be constructive critical thinking, reflection and discussion.

Tunstall and Bosse (2016) compared a traditional, lecture-based college algebra teaching with an online quantitative literacy learning method; the e-learning based on weekly news discussions as well as problem-based learning projects involving data analysis. The survey showed differences in students' mathematical disposition, attitude, and outlook on the use of mathematics; with the online group showing favourable outcome in each, which suggests that project-based e-learning environment is a promising strategy for fostering the affective component of quantitative literacy. However, they argued that much more research is needed to capture the mechanisms through which such growth occurs. Academic partnerships (2011) note that while there is evidence that students perform as well online than within a traditional teaching setting, there are equally many studies that show little or no significant difference between both. There are studies that show that the lecturer is the more important factor in that the instructor assures multimodal learning (Jackson, 2014; Walker et al, 2011; McCann, 2006); in which there is much student and teacher interaction (Bidaki et al, 2013; Abdous and Yen, 2010) within the teaching and learning process. It then seems that an effective teaching may be the most important fact no matter which delivery or teaching and learning method is used. Temple (2013) noted the blended type flipping classroom teaching and learning methodology together with quick student feedback on assessments led to much less lower grades and similarly low withdrawal rates from courses. The students tended to take less attempts to pass and were well satisfied with courses they took.

In case of the distance learning studies, there is also the sense of isolation or low level of self-directedness (Hanover Research Council, 2009). It also noted that the online teaching of the master's level courses have increased greatly with the business and education programs being most popular (Academic Partnerships, 2011). But some studies have showed no significant difference in student performance between the methods, rather the GPA had a significant effect on exam performance (Trawick et al., 2010). This suggests students need to be much more prepared before choosing a particular course for themselves.

In the end developments such as skype and various novel conferencing systems have all helped e-learning case. While the nature of the personal interaction between instructors and students has increased there is much increased demand on teachers or lecturers to develop new ways to present notes etc. and to become facilitators or coaches rather than lecturers. Moreover, the attrition of online mathematics students was found to be significant while in the traditional case, students did not in the end perform significantly poorly. It is true that the most effective on-line content is expensive to produce and much funding is required but there is a great lack of it particularly at the tertiary level. There are some such as Descamps et al. (2006) who argue that e-learning may become another fad and in the long run may not improve the teaching mathematics. However, they do agree that student education without the information networks is not possible in 2016 and that students expect all equipment "to work perfectly" all the time (24/7). There will indeed be much need for redesigning of mathematics and statistics courses given the existing learning systems may not have been appropriate for learning; although ipad is now available it again will require lecture type of teaching. There are indeed a number of hidden curricula that is taught at universities that will be left out in online teaching such as socializing, and being with fellow students, studying diversity, discussing work in face to face interactions and networking etc. It can be argued that each aspect of online technology may need further investigation and research for there may be issues unique to each aspect of e-learning if it is to be an appropriate alternative.

4. Discussion and Conclusion

The studies have clearly shown that the e-learning option is more popular when compared with traditional classroom learning but there are many studies that show not so significant improvement findings or even no difference between the two methods as well. The studies show a number of advantages and disadvantages with several issues highlighted such as: discipline to discipline differences, lack of "real" interaction and collaborative learning opportunities, gender differences as females may favour online learning, differing personal learning styles causing difficulties in both cases, isolation factor particularly in distance learning, lack of student preparation for online study, or inappropriate choice of online courses, withdrawal rates from online courses are greater than traditional ones, nature of student self-directedness and motivation levels, fear of or inadequate knowledge of the tools of technology - frightening off many to use online courses are just a few important ones. For example, the students who require flexible schedules, independent work environments, and possess strong motivation levels prefer e-learning method. However, when students value real life explanations, hardcopy notes, "real" interactive discussion and conversations with others during learning or solving problems, the traditional method is appropriate.

The mathematics discipline has problems with both e-learning and traditional methods. The online students tend to be older and perhaps working more hours than others who are full time. But many students may have had long break from studies and due to the gap in mathematics knowledge find learning problematic; the cumulative nature of mathematics knowledge lead to large gaps in knowledge and such difficulties are not able to be effectively solved online. In mathematics, good quality online mathematics courses with appropriate learning and assessments tools are difficult to develop without funding, whereas the course can be easily delivered and monitored using computer technology by a teacher as it is in online videos for example – however, the many hidden aspects of interacting live with students is then lost of course; an expert teacher who uses computer based material to impart knowledge may be less costly and more effective in a blended learning model for example.

The above difficulties with mathematics teaching exist because if it did not there would be no need for traditional schooling at all for all could be done at home; all necessary education materials would be online, from even late child care primary through to tertiary. Importantly, also, presently, there would be much evidence of deep student learning and other significant improvements more generally; given that computer technology enhanced teaching methods have been around for more than 20 years and have been extensively used in institutions. The critical review suggests that let alone the content of a course, a student must now learn both the mathematical content and technological knowledge. Also, the student learning should be done in both independent as well as collaborative discussion working environments with appropriate allowance for learning styles. Therefore, we cannot assume simply the application of technological and online methods involving mathematical problem scenarios should or will automatically lead to the acquisition of a deep or structural understanding of the content or appropriate heuristics as is required in mathematics (Tularam, 2015). Rather what is presently noted is that many students (particularly those who are marginal students) try and use internet to solve their assignment problems. Although this is commendable and encouraged, what is noted is most of the students work is simply a copy from the net; and the same students are unable to explain any of their written work when questioned (Tularam, 2015).

When technology is used in mathematics via e-learning, students require much general problem solving knowledge to be successful in learning. It seems that the weaknesses noted in e-learning is of the same order as in other learning methods suggesting that there is no "one best method" of learning; in fact this is due to the complex nature of learning and teaching processes in that learning is adaptive, evolving and often not predictive (Hulsman et al, 2011, 2013). During problem solving there are multiple entry points and multiple heuristics but students often do not necessary rely on any of these, and even if they do students tend to be rather tunnel-visioned following a particular heuristic (not choosing another even when it fails to provides insights into the problem). Even when the students change to another method they often return to the earlier ones due to familiarity. Student "emotions" appear to be of major importance and therefore "only when students are simultaneously strong in both mathematical content and technology do both aspects truly enhance the other". In other words, learning from online is as difficult as learning from any other mode of delivery of mathematical content.

Both e-learning and traditional teaching provide opportunity to engage, problem solve, persist, but with probably varying levels of success dependent on learner emotions, motivations and styles. While the e-learning can provide students with differentiated individualized work that are appropriate to their needs; the traditional can provide the opportunity self-evaluate, collaborate, and discuss or question self-understandings with friends or teachers. In this way, the modern lecturer's mind frame may essentially remain the same but may involve adjustments to teaching. On balance we need to retain natural learning environments that allow personalized instruction but equally the traditional classroom learning where collaboration and social and group understanding can occur. The internet provides opportunities for discussion and collaboration but Quigley (2012) said "the internet limits opportunities for young students to develop social interaction skills that are critical to their overall emotional and social development" (p. 749). While young students may not have appropriate self-reflective abilities as the older ones, both groups tend to be more attentive in e-learning environments. Critically, however, this does not directly imply that mathematics learning is taking place even when some gains in routine academic testing may be noted. Students need to learn to be metacognitive - reflective and evaluative of their efforts as well as of others; also being able to identify errors in logic, typing, arithmetic etc. in solutions, which tend to be done more effectively in reading mathematical work as it is a language in itself which has to be mastered. These tend to be more effectively done in traditional learning contexts.

The social engagement and working to solve problems with peers help in the longer run for students to learn to cope with the pressures of real work environments. The e-learning environment does not effectively allow for the above. Rather, the e-leaning banks on the independence and self-motivation of learners, whereas attending tutorials and lectures tend to focus students (particularly first years) to meet and socialize in the learning process. Although some real interactions do occur in teacher emails or on skype discussions these are not considered "real" interactions or face to face interactions that teach students the hidden curricula of universities as schools are for younger persons. It is noted that real "emotions" also play a part in learning and problem solving process and in mathematics for example, emails do not provide appropriate communication platform of this aspect; not to mention where typing of symbolic details often requires a lot of time etc. presently.

A US (Common Core Standards state from Engage NY, 2014) study did note that "students engage in rich and rigorous evidence based conversations about text" (p. 1) but this aspect is particularly discipline specific. There are difficulties with learning styles, with low levels of attentiveness, and low self-directedness as noted in e-learning. Students will need to take on self-responsibility for decisions about what and how they are to learn but each of these can be equally learned in traditional classes. Often students will need to become familiar with the varied technology devices, such as Matlab, SAS, Mathematica, SPSS, skype, message banks, smart phones etc. in order to be an active participant but this does take much time and often in a personalized instruction manner. In the end, learners will need to seek and learn to enjoy discovery, which is almost always done better in social or traditional learning contexts (Bryan, 2015). What the literature shows is that learning should at least become flexible with the availability of technology and e-learning methods but most importantly, educators should focus on how to improve student outcomes in mathematics, science and engineering (Jackson, 2014). But there are also the questions about whether some students are simply not prepared for the choice they make thus setting themselves up for failure. There are questions such as should the students be restricted from taking online courses if they have not reached a certain GPA? Or should students who fail or withdraw from an online course be required to take to traditional courses? A higher withdrawal rate, failure rate and incompletion of assignments by the deadline occur online yet students' academic achievement, engagement, and positive behaviour were noted in the el-learning environment. Students tended to be more attentive and on-task as well as engaged within an e-learning environment. In contrast, in traditional environment student also showed good academic achievement but with a reflective, evaluative, and deeper understanding with constant persistent effort within the traditional environment and these were more related to their social learning, interactions, networks, friendly collaborations etc. Clearly, these cannot be claimed to during independent e-learning at least presently.

In conclusion, the critical review suggests that teachers should use computer assisted instruction software and realize that the novelty will wear off novel after initial student motivations. The process of learning e-learning may also become as mundane as traditional teaching and this has now noted in modern classrooms around worldwide. So the computer assisted learning may be more a supplemental tool for teaching. Yet whether the delivery is done face-to-face, online, chat, texting, or discussion boards etc., the continued success of students with marginal cumulative GPA's shows personal contact with lecturers as particularly important regardless of the method of delivery but there is a need for much more research.

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Development of the effective system of cloud technologies for the engineering education sector of the Republic of Kazakhstan

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The paper shows the results of the study of possibility to develop effective cloud services for the sphere of engineering education in Kazakhstan at the present stage. Based on analysis of existing cloud-based solutions of the largest cloud providers, the cloud platform Windows Azure was chosen to host the educational cloud SaaS service. The designed version of the software architecture of the system has the following feature. The site core is located in the cloud hosting Windows Azure. CMS Drupal is installed using MS SQL database. Modules of the educational Saas cloud service: "Teacher", "Student", "Data storage", " Online office ", "Testing" are integrated on site into service with CMS Drupal. Module "Teacher" interacts with the module "Student" and with the module "Data Storage" via service (web site), developed on the base of Drupal. The process of data sharing in the "Data Storage" module is synchronized with Google Drive and functions via opening access to files and folders for all members or authorized users of the system. The site backup is stored in the cloud storage Dropbox. Taking into account the presented software architecture of cloud services and features of its main elements, the model of educational cloud service SaaS was developed. The architecture, basic modules, the principle of operation of the system and models were taken into account in the development of the algorithms complex for cloud service. For a software implementation of the tasks in the work we made an justified choice and gave a detailed description of the cloud platform and packages of system, tool and application software. Multifunctional module «Online Office» was developed, which works on Google Docs platform, performing functions of corporate instant messaging. The system start was done in the cloud, and the developed complex of educational services were tested at educational materials of engineering specialties, showing its performance and high efficiency.

Keywords: engineering education, cloud computing, cloud platforms, cloud services

Introduction

Development of efficient cloud services for the sector of engineering education in Kazakhstan is important not only against the background of the use of cloud computing in today's stage. In the opinion of authors Vanachek (2012), T.V.Batura, F.A.Murzin, D.F.Semich (2014) it is due to the following factors: time savings, as there is no need for continuous monitoring of technical facilities and their condition, the lack of large investments, automated and scalable projects, which positively affects the work and further growth of the university, as well as data security and flexibility in the organization of educational process.

The main purpose of this work is to study the possibilities of developing an effective system of cloud-based solutions for the education sector of the Republic of Kazakhstan at the present stage. In accordance with the intended purpose of the work it is necessary to substantiate and develop a cloud-making system in the form of easily scalable, flexible, accessible and secure web-based applications.

Designed service must be suitable for practical use, and contain all the necessary services of such class**.**

1 Development of models and modules of the cloud solutions system for education sector of Kazakhstan

The proposed architecture of cloud services system for education sector in Kazakhstan is presented in Figure 1.

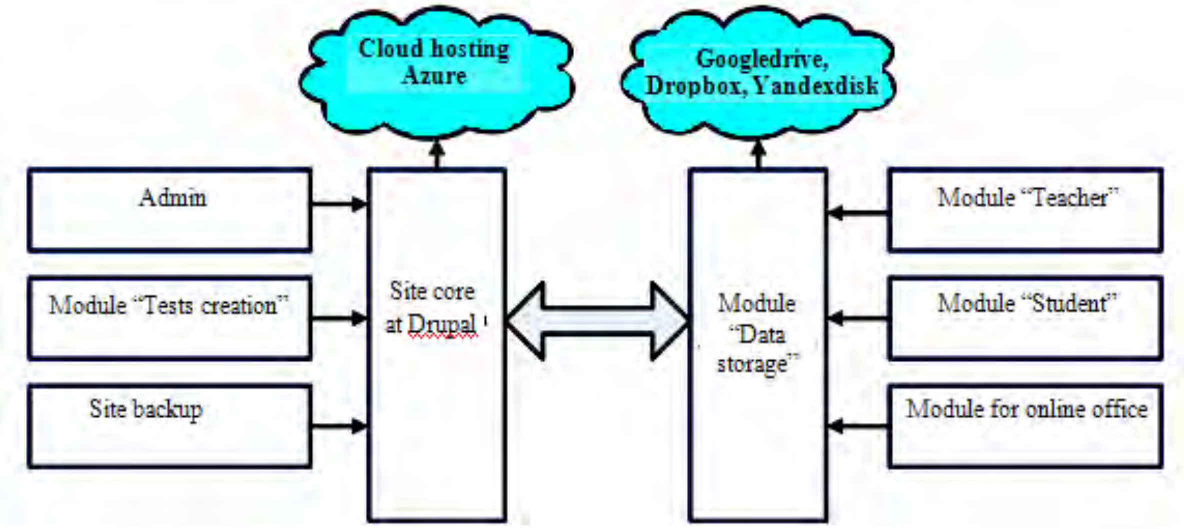

Figure 1 Architecture of cloud services system for education sector in Kazakhstan

Based on analysis of existing cloud-based solutions of the largest cloud providers, the cloud platform Windows Azure was chosen to host the educational cloud service SaaS (software as a service). The detailed description of main elements of the developed model of cloud service is presented in th works by Utepbergenov, Naraliev, Baymuratov, Galiyeva (2015), Utepbergenov, Galiyeva (2015).

The site core is located in the cloud hosting Windows Azure. CMS Drupal (Content management system Drupal) is installed using MS SQL database. Modules of the educational SaaS cloud service: "Teacher", "Student", "Data storage", " Online office ", "Testing" are integrated on site into service with CMS Drupal. Module "Teacher" interacts with the module "Student" and with the module "Data Storage" via service (web site), developed on the base of CMS Drupal.

The process of data sharing in the "Data Storage" module is synchronized with Google Drive cloud store (as well, it is possible to use other stores, for example, Dropbox or Yandex disc) and it functions via opening access to files and folders for all members or authorized users of the system.

Administrator of the site core at Drupal periodically performs Backup to Dropbox via the module Backup Migrate.

2 Development of the model, functional structure of SaaS solutions and modules of cloud services system

In the light of the system architecture of cloud services for education sector in Kazakhstan (Figure 1) and the main features of its elements, the model of cloud service was developed.

Algorithm of the developed cloud service for education sector is based on the algorithms presented in the works by Safonov (2012), Fingar (2011) and the works of the authors of this report Utepbergenov, Baizyldayeva, Nurmagambetova (2014), Utepbergenov, Baizyldayeva, Iskakova (2014), Utepbergenov, Baizyldayeva, Uskenbaeva, Iskakova, Berkimbayeva, Nurmagambetova

(2015), Utepbergenov, Muslimova, Utegenova, Baizyldayeva, Kubekov (2015), Utepbergenov, Galiyeva (2015).
The architecture, basic modules, the principle of operation of the system and models were taken into account in the development of the algorithms complex for cloud service.
The information system SaaS based on the cloud technologies was developed as the main cloud service for education sector in Kazakhstan. The project is a set of measures and tools to create a cloud SaaS. The functional structure of SaaS system is shown in Figure 2.

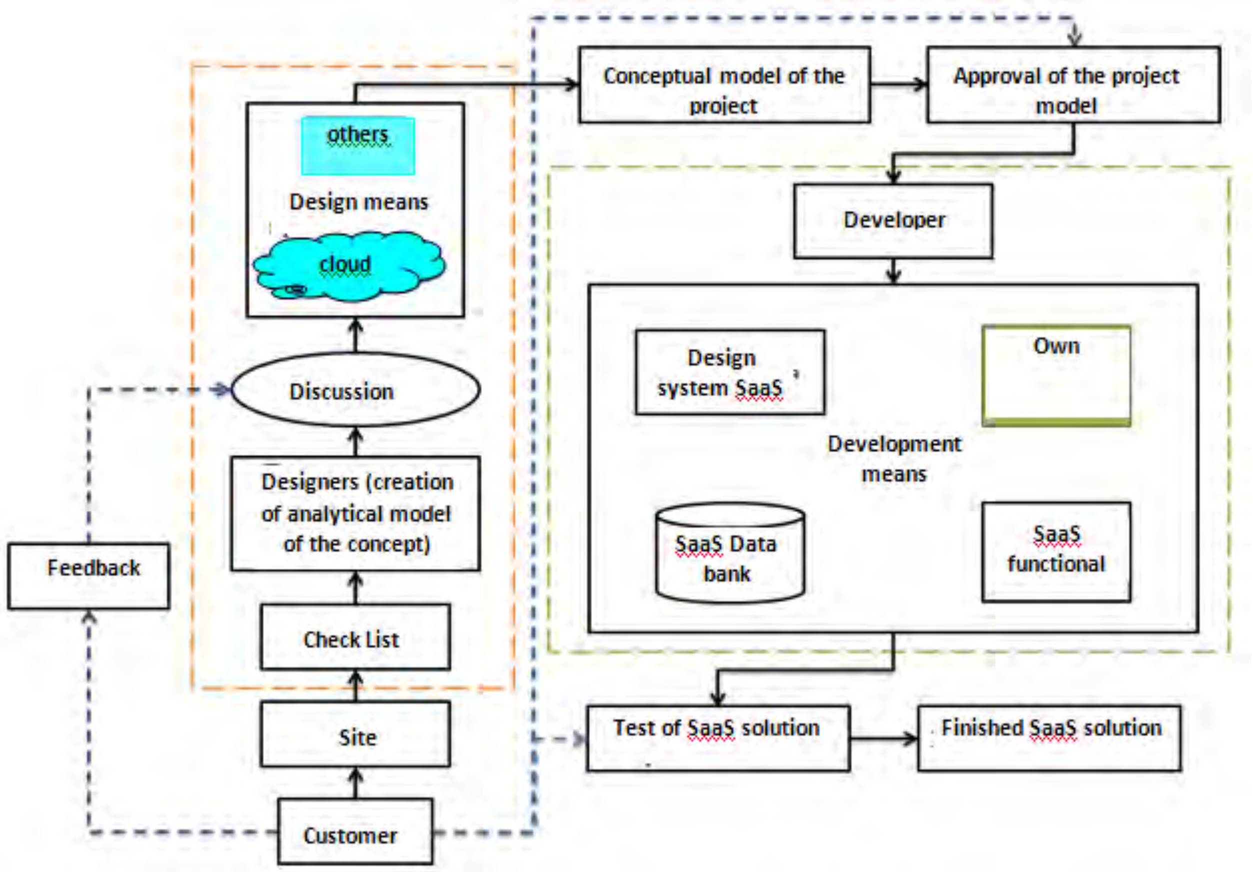

Figure 2 The functional structure of SaaS system

Customer – an Educational Institution (University, education department of the region, oblast, etc.) interested in integrating of educational services or cloud solutions using cloud technology into their own information system. Customer acts as the initiator and the cloud-based solution formed in the design and development process is oriented on him.
Check list – a form containing non-formalized description of the required solutions. It is the main communication means at an early stage of the design.
Designer – a performer, fulfilling the following functions: processing the questionnaires completed by the customer, building a model based on data from the check list, discussing this model with the customer and creating a conceptual model, based on which the project is built.
Discussion - the process of discussing the model created by the designer based on data from the customer's check list. The result of the discussion is a conceptual model of the designed system.
Design Tools - application and tool software, techniques and principles used in the design process. The cloud design tools are indicated in the scheme as an example of the use of cloud technologies for the development of information systems.

The result of the design phase of the project is a conceptual model of information system - an abstract model that defines the structure of the simulated system, the properties of its components, and cause-effect relationships inherent to the system and are essential to achieve the objective of modeling - creation of efficient cloud service.
Approval of the draft model - a conceptual model, approved by the customer, subsequently implemented by developers.
Developer - Specialist implementing conceptual model of the project in practice. Also, the developer implements the technical support of the project. The computing and software resources of the cloud platform Windows Azure are mainly used in the process of development.
Development tools - tool, application and system software and other tools used in the process of building, testing, improvement and maintenance of the final product. Also, the software written by developers is used actively in development, these are templates, small programs, modules and software for testing.
Testing of SaaS solutions - testing of the finished project in the dedicated environment. The unaccounted features of the software are revealed in the process of testing and measures are taken to remedy any mistakes.
Turnkey SaaS solution - cloud service, suitable and used for its intended purpose, presenting implementation of the project conceptual model approved by the customer. The finished project is not the final design stage and can be modified due to changes in customer requirements to the product or changes in architecture of the cloud platform.

3 Generalized algorithm of the system operation

Information system SaaS includes several stages of creating a cloud service.
"Cloud" is a new business model for the providing and receiving of informational educational services. This model allows not only to reduce operational and capital costs, but it increases actually the effectiveness of innovative educational process.
Step 1: Start (Figure 2).
Step 2: The company wants to implement cloud services into its business model. It may be a document management system, special tools specific to the customer's area of work, but transferred to a cloud platform, cloud storage of data or any other plan for cloud use. Customer choses cloud technologies for implementation of his business processes and methods which should be used for the implementation of integration. In order to understand the customer, which may have a misconception about cloud technology, and to understand his needs, the customer fills in a check list which describes most clearly the result of the upcoming work. Further, the designers take the check list, analyze customer requirements and build an analytical model of the concept of information system, using all the available design tools, including the cloud. Besides, the dialogue with the customer is continuing during the design phase, and the customer takes an active part in the discussion, formulation and approval of the analytical model of the model concept. Also, during the development, the customer gets to understand working principles of cloud services and the vast possibilities of using SaaS cloud technologies.
Step 3. The result of the design phase is an analytical model of the concept of information system - an abstract model that defines the structure of the simulated system, the properties of its components, and cause-effect relationships inherent in the system and are essential to achieve the goal of modeling - creation of efficient cloud service. The analytical model of the concept must be approved by the customer in order to begin to implement it in practice.
Step 4: After the approval of the analytical model of the concept with the customer, the project moves to the development stage. At this stage, the developers begin to assemble the product, using intensively model design tools for cloud software as a service. Also, developers use their own tools and blanks / templates to accelerate the development of the project and to reduce routine work.

Step 5: Test of the created solution. Testing is performed in order to identify problems in implementation of the final version of the cloud services to the customer of educational services.
Step 6. Customer implements the designed system on the test machines, or in a particular segment of his computer system for review, conducts stress tests, identifies problems of integration and technical features of the work. After the test run of the system, the final adjustment of the elements is done, and minor faults and shortcomings are fixed.
Step 7. After successful end of tests, the solution is ready for implementation in the educational institutions. Further support of the solution is based on the agreement with the customer, and may include the further development of the solution, technical support and maintenance of the developed solutions, and so on.
Step 8. The end.

4 Start and testing of the service

The developed complex of educational services was run in the cloud and tested for research purposes. To start SaaS «EduCloudKz» service one should open the window of any browser (eg, Internet Explorer, Opera, Firefox, Chrome). In the address bar one should specify the URL - address http://educloudportal.azurewebsites.net.
After that, enter the username and password for the account in the section "Sign in". In this version of the site, there are 3 types of accounts: administrator, teacher, student.
Designed complex of educational services can be used for various educational specialties. As engineering specialties, namely IT specialty, were closer for the developers, so the test was performed on the learning materials of engineering specialties data.
Some screen forms of cloud services in test mode in Russian are presented in the following figures.
Figure 3 is a page of "Student" account in the site.

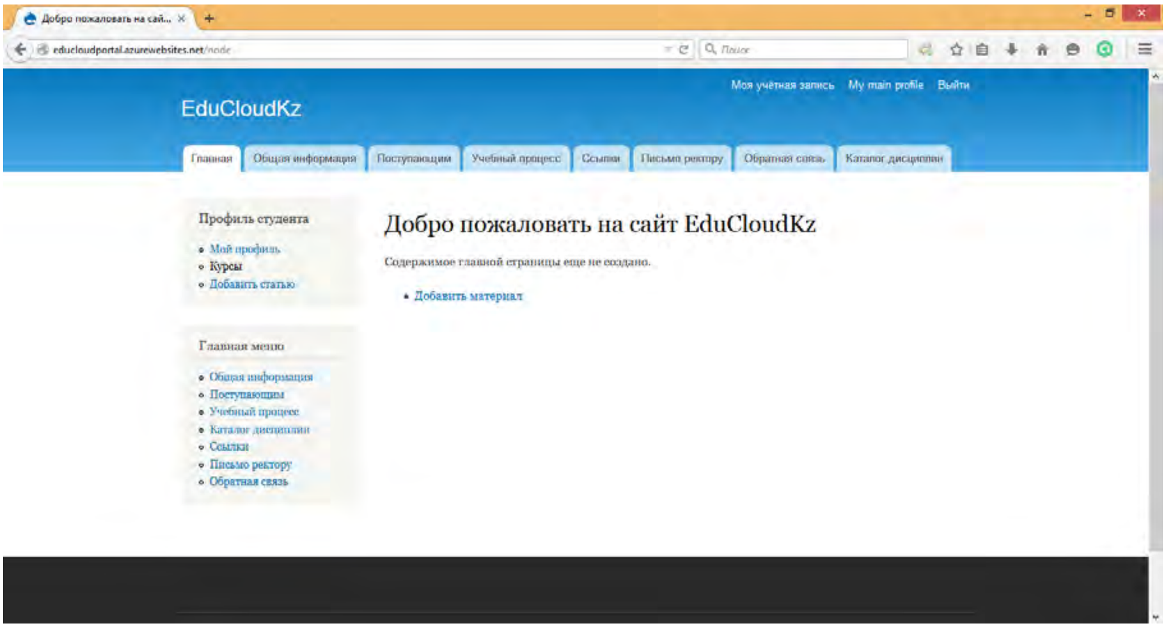

Figure 3 Page of "Student" account

Page «My profile» of the account «Teacher» is shown in Figure 4.

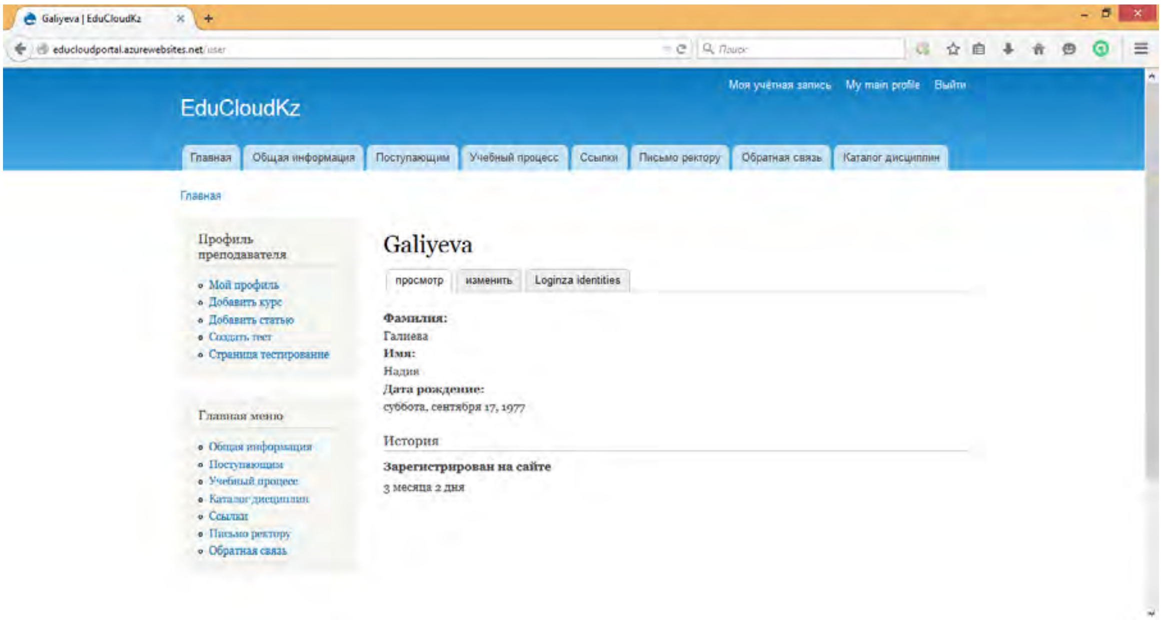

Figure 4 Page «My profile» of the account «Teacher»

Testing of the developed program has shown that the complex of educational cloud services «EduCloudKz» satisfies the basic needs of educational institutions of the Republic of Kazakhstan in the application of innovative cloud technology.

5 Conclusions

1. Based on analysis of existing cloud-based solutions of the largest cloud providers, the cloud platform Windows Azure was chosen to host the educational cloud service SaaS (software as a service).
2. Development of architecture, model and functional structure of an information system on the SaaS-based cloud was implemented.
3. A generalized algorithm is developed for implementation of the cloud service in the sector of education.
4. The developed complex of educational services was run in the cloud and tested, it indicates the possibility of developing an effective cloud service for engineering education in Kazakhstan using the latest available packages of system, tool and application software. The developed effective educational complex of cloud services «EduCloudKz» satisfies the needs of educational institutions in the application of innovative cloud technology in the Republic of Kazakhstan.

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The Assessment of Engineering Student Public Speaking Ability: What, How and Issues.

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Abstract: This paper discusses the assessment of public speaking as a generic skill in engineering students. The assessment is far from a new topic however there are a few fundamental questions surrounding this generic skill that remain unclear and subject to a number of measurement issues. The paper commences on the premise that public speaking is actually a meta-competence which sits in the middle of a hierarchy of skill definitions under the general umbrella of communication. Below it are skills such as: the ability to convey a technical subject to a lay audience; the ability to convey a technical subject to a technical audience; and a number of other variants. The paper then considers some of the issues with measuring it as a skill starting with why, as academics, we should measure it and what any statement of ability means. It looks at issues of measurement reliability and validity and some of the common sources of conscious and unconscious measurement bias. The paper will draw on the findings of 3 years experimental research at the University of York into the use of a marking rubric and how effective this is compared to the more common overall assessment methods. It will also report on the need for assessment of how well the student can defend their presentation and the more controversial question of whether, if a student shows complete incompetence in being able to defend their presentation whether they should pass or fail the overall presentation.

Keywords: Engineering education, Public Speaking, Assessment, Assessment bias, Students

1. Introduction

A search on the Internet for "Public Speaking" yields over 36 million references, including advertisements, images, hints and tips, informational articles, TED talks, you name it there is something related to public speaking. Narrowing the search to '"Public speaking" & Books' yields over 1.7 million hits. Narrowing down even more to '"Public speaking" & Books & pdf' yields over 600 thousand hits. A search of Google Scholar using "Public Speaking" yields 128 thousand hits. There is a vast amount of readily information on the topic, too much to systematically review without a considerably tighter focus.

The Wikipedia (2016) definition of Public Speaking is "*Public speaking (sometimes termed oratory or oration) is the process or act of performing a presentation (a speech) focused around an individual direct speech to a live audience in a structured, deliberate manner in order to inform, influence, or entertain them.*" By this definition public speaking is a form of "*imparting or transmission of something …*" the stem of the definition of 'communication' OED (2016). Viewing skills in a hierarchical sense and using these definitions as a starting point would support an initial view that 'communication' is one or more levels of abstraction above public speaking.

The definition gives a starting point to a number of questions that arise in a detailed investigation into public speaking as a skill. The primary context for this question is in the development of it as a generic skill in students within the Higher Education system.

At the fundamental level what is public speaking? Is it an Act or a Process, an art or science? Definitions of the term vary considerably, for example the online dictionary defines it as "*the act of delivering speeches in public*" dictionary.com (2016); speechmastery.com defines it as a process: "*The process of speaking to a few or many people with the purpose of informing, motivating, persuading, educating or entertaining the listeners.*" Speechmastery.com (2016); while the Merriam Webster's definition allows it to be both in its definition: "*The act or process of making speeches in public*" Merriam (2016). The dictionary.com also defines it as "*The art or skill of addressing an audience effectively*" Dictionary.com (2016), as does Lucas (2009) in his aptly named book "*The art of public speaking*", whilst others refer to it as an art and science for example in "*Between one and many: The art and Science of Public Speaking*" by Brydon and Scott (2010).

Two different methodologies were used to inform the discussion and results presented in this paper, firstly, using desk research, dictionary definitions and academic literature were reviewed to explore public speaking as a construct and how it fits into a hierarchy. No specific age range or academic level was used in this search although references at the Higher Education level were generally favoured. The second method involved the downloading of job advertisements from online job search sites in the technical areas of renewable energies and biomedical engineering. The objective of this side of the study is to open a window to one way in which employers express their need for public speaking as a skill. This part of the work does have an engineering related bias because only engineering and related job adverts were sought. A fuller description of the job advertisement side of the research is given in section 3. The following section briefly explores the literature side of public speaking.

2. Public Speaking

A review of some of the mass of literature on public speaking shows there are a number of different purposes to the presentation. Three general types seem to emerge, to Commemorate or entertain; to Inform; and to Persuade. When commemorating or entertaining the objective is to "*strengthen the bonds between audience members from recalling a shared experience or intend to amuse audiences through humor, stories, or illustrations*" Schreiber et al (2011). For this type of presentation a number of examples are given, including after dinner speeches (e.g. Boom (1992)), Award acceptance speech, Eulogy, Graduation opening, Wedding speech. Informational includes Classes or lectures and Conference presentations; Persuasion includes politician's campaigns, public debates and sales pitches. Are these all the same types of presentation?

The audience is also important, Grippo (Book) said: "*use technical language on your visuals only if you are speaking to a technical audience; use common terms for a lay audience*". From this can we infer that the skill of presenting to a technical audience is different to a lay audience? According to Peterson (2012) audience size also matters: "*The size of an audience affects speech delivery; a small audience can be addressed informally, while a large audience requires more structure.*" Does differentiating between a large and small audience merit different definitions? The issue of the audience was one of three 'contradictions' Dannels (2003) explored. When giving a presentation during their study programme "*Should students address an academic or a workplace audience, which they defined as purely technical or mixed, respectively? Should students speak as students* *working for a grade or as practicing engineers? Should students orally structure their presentations using the step-by-step design process their textbook identified or using the problem oriented focus they believed characterized workplace design?*" Dannels (2003).

Manko (1969) states that speechmaking is not difficult, it just needs "planning and thorough preparation". Perhaps herein lies the clue to a similarity between all these types of presentation, they all need planning and thorough presentation if the desired effect is to be fully achieved. But does that make them all the same?

3. Job advert analysis

The full text of 92 job advertisements were downloaded from the internet into the NVivo qualitative research analysis tool as 'Internals' for this analysis, comprising 36 Biomedical Engineering, 13 Hydro energy and 43 Solar Power adverts. Mentions of communications, write, speak and listen including all stemmed words were all initially coded into a single node. In addition the adjectives used to indicate the level of ability required or desired for these skills were also coded.

41 of the job adverts (44.5% of all adverts) had some of their text coded at communications. This was surprisingly low as the ability to communicate might be thought of as important in all jobs. To test to ensure nothing had been missed, a sample of the job adverts not coded at this node or any of its sub-nodes, were checked for missed references. None were found.

To refine the coding and start to develop a job advert derived hierarchy, the text at that node was reviewed and recoded to lower level skills where this could be done. On inspection it became clear that there were a number of 'dimensions' associated with communications as a skill, the dimensions, excluding the skill itself, and their sub-nodes are shown in Table 1

Table 1 Dimensions of "Communication"

Dimension	Sub-nodes
Audience level	All, Client, Senior Management or Board, Staff
Audience Type	Lay, Technical
Contexts	Articles for publication, Customer focused, Documentation, Proposals, Reports, Review of others' work, Specifications, Speeches, Technical Sales
Mediums	email, Telephone

The skills were coded into the following hierarchy:

- Communications
    - Communications (30)
    - Listening (1)
    - Verbal or Oral (12)
        - Presentation (3)
    - Written (20)

Mentions were coded at "Communications (30)" above when there was not further elaboration or definition of the meaning. In the above list the number in brackets is the number of times the term is used in the adverts. Where the term "Communications" is used the exact detail of what is being sought is unclear. Clarity in this respect only emerges from the more richly expressed needs. For example in the Presentation sub-node, one advert states "*Effectively present information to a variety of people, including senior management, groups, and/or board of directors.*" This shows that the company, at least on the face of it, considers presenting to these different groups may be somewhat different. In a similar way "*Excellent verbal and written communication skills; including communicating with technical and non-technical clients and staff*" suggests the company recognises a difference in communicating with technical and non-technical people. Whether this extract from the advert also implies there is a difference between communicating to staff and clients may be a step too far, it may just be indicative of the nature of the role. Another advert states "*Strong communication skills in all forms including written, oral, email, telephone*" again suggesting an ability to communicate using a number of different mediums may, to them be different.

The context of the communication extracted from the adverts also offers some insights into differences employers needs. Contexts vary from: user documentation, as in "*Writing user documentation to a high standard*", technical documentation, as in "*Technical writing for project documents*" and sales support materials, "*You're highly numerate and a brilliant communicator who enjoys using high quality sales support materials*"; Proposals; Reports; Specifications; and Articles for Publication. Reviewing of other's writing is mentioned in one, "*as well as review of junior engineers' technical writing*", arguably a different skill to writing oneself.

Some adverts inform the hierarchical nature of communications as a meta-skill, as in "*great communication skills - verbal, written, listening with a strong customer focus*", others support this through the use of the 'and' conjunctive, as in "*Excellent verbal and written communication skills*" and *"Excellent communication and presentation skills*".

In initial conclusion to the job advert analysis section of this review, the analysis supports the argument that communications is a higher-level skill and that public speaking, as expressed as 'presentation' falls within it. It further suggests that simply to give a presentation may be a simplistic view of what employers require and that dimensions such as audience level and technical ability are important and possibly viewed as being different.

4. Assessing Public Speaking ability

Lord Kelvin, in his "Electrical Units of Measurement" Kelvin (1883) said: "*I often say that when you can measure what you are speaking about, and express it in numbers, you know something about it; but when you cannot express it in numbers, your knowledge is of a meagre and unsatisfactory kind; it may be the beginning of knowledge, but you have scarcely, in your thoughts, advanced to the stage of science, whatever the matter may be.*" Whilst this is an engineering related quotation the basic principle that if you cannot measure an entity you cannot control it or know whether you are developing it or not is fundamentally still valid. The same should apply to the assessment of a student's ability in the generic skills. But how practical is this? To be able to assess an entity we need to be able to define it and then establish a measure that interested stakeholders all accept as being meaningful, then the assessment methods to deliver said measure should be considered.

Higher Education is very used to assessing student ability, especially in technical skills. Assessment instruments, such as examinations, laboratory write-ups and assignments are mature as are the underlying quality control systems (through peer review, moderation and random cross-checking processes). The results are frequently in percentage form and from that translated into either a letter or numerical grade or a Grade Point Average. In all cases the scale onto which the student marks are mapped has accepted meaning generally to all interested stakeholders. The overall grade of the award, whether it is the UK system of 1st, Upper 2nd, Lower 2nd, 3rd and Pass class degrees, or alternative systems, has meaning to local employers who understand the quality implied when in conjunction with the name of the awarding institution. The same can be said for the detail within the student transcript, which details exactly how well (the warranted level of ability) the student has performed in each of the academic modules they have been assessed in.

This is in contrast to the generic skills where there is an understanding of what they mean, up to a point, but much less attention to detail in their specification and assessment. By way of example the Washington Accord, includes: "*Communicate effectively on complex engineering activities with the engineering community and with society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions*" as a required graduate outcome of academic programmes, Hanrahan (2009). In this definition we again see the parts of a skills hierarchy underneath 'communications' with 'effective' as the ability level and 'the engineering community' (technical) and with 'society at large' (lay) audiences included. The conjunction used in the statement is 'and' implying that the student needs to be able to do all – to warrant this we should assess the student in presenting to a technical and a lay audience. Section 7.8 of the UK "Subject Benchmark Statements: Engineering", 2015, states: "*An implication of defining output standards for engineering degrees is that all students graduating with such degrees are able to demonstrate that they have achieved these standards. Programme providers need to make clear how this is ensured.*" and section 7.9: "*Assessment is the means by which students are measured against benchmark criteria and also forms a constructive part of the learning process*." Assessment, including for generic skills as these have a place in the benchmark statements, is therefore a requirement of academic programmes. The challenge now becomes what we measure and how we assess and certify the student ability. As a starter in this direction, what does industry want? A window into this is again through job adverts. Whereas academia may look to grades or percentages as the method of specifying ability the analysis of job adverts shows a very different way of specifying level of ability for both technical and generic skills. Table 2 shows the adjectives attached to each skill within the skills hierarchy as extracted from the job adverts. The table shows the number of times each adjective (rows) are mentioned for each skill sorted in descending order of total number. The total column being the total number of times that adjective is used across all skills. The adjectives used are, by definition descriptive, subjective and difficult to place in rank order let alone referencing them meaningfully to any externally warrantable scale.

Table 2 Adjectives used in conjunction with communication skills

	Communications	Listening	Verbal Oral	Presentation	Written	Total
Excellent	10		4	2	6	22
Strong	12	1	4		5	22
Good	1		1		2	4
Proficient(cy)			2		2	4
Fluent			1		2	3
Great		1	1		1	3
Clearly	2					2
Effective(ly)	1			1		2
High					2	2
High Standard					2	2
Proven	1				1	2
Brilliant	1					1

For public speaking, a considerable amount of effort has gone into the development of public speaking assessment rubrics with examples being the Public Speaking Competence Rubric (PSCR) developed by Schreiber et al (2012). A limitation of this rubric and of many others, is the lack of assessment of how well the student can defend what they are presenting (from a technical point of view). For Engineers, in Sales and Marketing, Business Proposals and more, the ability to defend and argue the case is important, which led to an evolution of the PSCR to include the assessment of the presenters' ability to defend their content Jackson et al (2014).

The modified rubric has been used for over 3 years at the University of York to assess undergraduate and taught masters level presentations using academic and student peer assessors. The detailed results of over 5,000 assessments have been used to test inter-assessor reliability, bias and the effects of assessor fatigue when a sequence of presentations are being assessed. Initial details of findings of analyses completed to date can be found in Jackson and Ward (2014), Ward et al (2016). The findings show that where the marking rubric has been used there is high correlation between marks awarded for the same presentation by trained academic markers, no statistical evidence of gender bias, and no predictable effects of marker fatigue.

5. Discussion

In the case of generic skills we are very close to being at stage 1 of the assessment process, still requiring clear definitions of the entity we are trying to measure. In the case of public speaking there is disagreement on whether it is an Art or Science or an Act or Process – these distinctions may seem trivial until we consider the approaches taken in different academic disciplines to assessment – in the Sciences there is more likely to be a right or wrong answer, measurement is a very important component of education. Is the same true in the Arts based subjects? Do we objectively try to measure the quality of a picture, an essay, a literary work?

Is public speaking an act or a process? Assessing it as an 'act', a one off activity is fine but is this a good predictor of how well the individual will give their next presentation – where the brief or 'scaffold' may be completely different. Ward (2012) argues that the ability to demonstrate the student can follow the 'Generic public speaking process' to produce a good presentation is a more robust predictor of their future ability. The use of assessment rubrics is an effective way of assessing this ability, improve inter-marker consistency and reduce marker bias effects. However this does not affect the need to be clear what it is that is being assessed, for example is presenting to a technical audience the same as presenting to a non-technical audience? Two of the companies in the job advert state the ability to present to both types of audience is required, as in "*Excellent verbal and written communication skills; including communicating with technical and non-technical clients and staff*" and "*Experience writing speeches and articles for publications that conform to prescribed style and format both for technical review and in layman's terms.*" Indicators of a recognisable and desired difference.

The Engineering Benchmark Statements make it clear that all output statements must be met if the student is to be certified as meeting the overall standard. Where the benchmark statement is, itself a compound statement, we should also imply that the student needs to meet all aspects of the statement. In the case of public speaking this implies the student can present to a technical audience AND a lay audience. If, in addition to this assumption, the more predictive model of student ability to give presentations, that is the process rather than act view, is the ability to demonstrate competence in all stages of the process equally important? This begs the question if a student is unable to demonstrate achievement of a benchmark minimum ability in a component of an assessment should they fail that assessment? Two specific, and very controversial directly applicable examples of this are where a module is assessed by both a written assignment (perhaps a report) and a presentation. If the student fails the presentation do they fail the module? At a deeper level, if the presentation has a number of assessed components, one of which is the ability to defend their presentation in questioning, and they cannot, should they fail the presentation and/or the module the presentation is part of? In a short survey of academics in the Department of Electronics at York not one academic agreed that the student should fail if they could not defend their presentation – yet in Industry if the employee could not defend their presentation would this be acceptable? Compensation is clearly the academic desired way out here but is it right?

6. Conclusion

This paper does not offer answers, rather it is designed to expose some of the difficult questions that lie beneath the skin of Higher Educations' part in the development of communications' ability in students, in particular public speaking. The conclusion reached is that communication is a meta-competence with public speaking as a sub-competence. Academia regularly assesses student ability in public speaking but there are problems in what is assessed and the way in which ability is certified. Even with its experience in assessment, which for technical subjects is very mature, the assessment of public speaking skills is still relatively weak but improving. Industry, as it articulates needs through job adverts, is currently in a very different place to academia with definitions of ability firmly set in subjective adjectives. There is much room for improvement in this subject.

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Transitioning to online delivery-a model for tertiary foundation engineering courses

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Abstract: This paper proposes a model for transitioning the delivery of first year tertiary engineering courses from face-to-face environments to variable delivery modes employed in tertiary education to meet changing demand. There is movement towards online delivery of university courses, even consideration of whole programs online for external mode delivery, sometimes aided with significant university support and investment. However, not all courses/programs are selected for 'make-overs' using the available university infrastructure. Individual practitioners and engineering course teams need to consider how they can independently prepare and implement a staged introduction of aspects of online delivery in a sequential and safe manner. The transition to online can be thought of as various stages of development from face-to-face, blended learning, flipped classrooms, online external with intensive on-campus practicals to fully online with practical equivalents. Course-specific student support structures for the change in learning approach from teacher-led, to student-centred, need to be trialled and developed; new resources created and analysed and new learning activities devised - all while evaluating the impact on students' learning and their transition to university study. This paper presents this model and maps the sequential development of an engineering physics course over three years from face-to-face to blended and then flipped delivery of the lecture component, and monitors the impact on different student groups' behaviour, engagement and learning outcomes using a variety of techniques available to individual course teams.

Keywords: Online learning, Blended learning, Flipped classrooms, Course development, First year engineering

1. Introduction

1.1 The global push for online learning

Today's universities compete in a global marketplace which has been enabled by innovation and digital technologies (Ernst & Young, 2012). Increased flexibility in STEM within tertiary learning environments is included as a part of a national strategy to secure Australia's prosperity (Chubb, 2013). One driver for this change is students. Contemporary university students have greater access to information, are more mobile and are juggling more competing commitments (Coates & McCormick, 2014). Despite hurdles, such as the practical component, and aging academia reluctant to engage with the online modality (Mayadas et al., 2009), it is predicted that online engineering programs, that allow learning anywhere and anytime, will continue to develop and improve (Bourne et al., 2005).

1.2 Changing course delivery

Face-to-face (F2F) offerings of engineering courses at university usually involve lectures and tutorials, with or without practicals. Blended learning is defined as the convergence of online technologies with F2F instruction to optimise student engagement in the learning process and provide greater flexibility in study (Dawson, 2015). Flipped learning has been defined as consisting of two parts: interactive group learning activities inside the classroom, and direct computer-based individualised instruction outside the classroom (Bishop & Verleger, 2013). Online learning is when all course curriculum and learning activities are completed online, and students are not required to attend a physical campus (Dawson, 2015).

Universities often engage institution-wide strategies to increase the number and quality of online courses available, sometimes with teams of people descending on selected courses or an entire program and completing 'extreme makeovers' in a relatively short period of time (James et al., 2011). Course design is seen as an 'enabling agent' (Goodyear, 2013) to allow pedagogical changes such as constructive alignment (Biggs & Tang, 2011), online resource creation, activity and assessment re-focus and design, and more sophisticated website creation to support a switch from teacher-led to student-centred pedagogies.

But what of those courses that are not targeted for these makeovers by (course) renovation teams? We propose that it is possible for individual coordinators or engineering course teams, over several years, to independently change from F2F, to blended learning, to flipped classrooms and eventually to high quality fully online courses, by first understanding the cohort, creating online media, developing relevant and engaging F2F learning activities and then later, translating these to online equivalents (Figure 1). By closely monitoring the impact of this staged introduction on students, high quality robust learning environments can be progressively created.

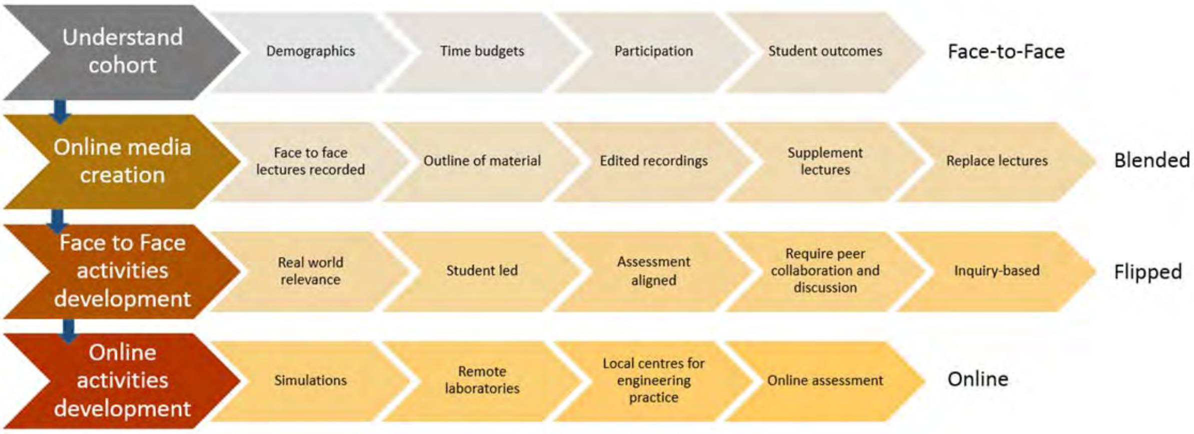


Figure 1 Model of progressive course development from face-to-face to online delivery

Increased student diversity means that changes in learning environments will be better for some students, but not necessarily all. Although GPA can be used as a predictor of success in STEM courses (Hachey et al., 2015), personality factors such as perseverance and passion for long term goals (Duckworth et al., 2007) have been shown to be better predictors of academic success.

To demonstrate this model in action, we present aspects of a case study of 3, of a 5 year transition project for an engineering physics course. It examines how different students engage with components of the course at different stages of the transition and considers how students' incoming grade point average (GPA) and personality factors impact on student success.

1.3 Background

The course, Engineering Physics N, is a 2nd semester first-year course offered as a part of several electrical and electronic engineering bachelors programs. There are no prerequisites for this course however stage 2 (year 12) physics is assumed knowledge. While the intake is predominantly local students from the high school system, a number of students are international, from bridging and access pathways, repeat or mid-year entry students.

Assessment is via a 10 week Practical experience (25%), Continuous assessment using in-class quizzes and tests (25%), and a final Examination (50%).

Prior to 2014 the course was offered only in F2F mode. From 2014 online media has been added to allow blended learning and adjustments made to F2F activities to improve their relevance to real world contexts. In 2015, a transitional hybrid flipped classroom model was employed where only the first 4 weeks of traditional lectures were presented in parallel with online media and were then replaced by a single lecture-workshop for the remainder of the semester. In 2016, new F2F activities and online activities are being developed along with the first external offering (with an on-campus intensive for the practical component).

2. Methods

A detailed case study is presented showing the step-wise development and the evaluation processes employed for a second-semester first-year engineering physics course. Student participation in F2F events was by head count. Students' engagement with online resources was by hit counts recorded within the learning management system. Online surveys where used to assess students' 'overall satisfaction' at the end of the course and a short online quiz was used to assess students' passion and perseverance (Duckworth & Quinn, 2009). Standard metrics such as grade point average (a 7-point scale) and grade outcomes were used to evaluate student learning outcomes.

3. Results

3.1 Understanding the cohort

The transition to university study that includes online environments involves a shift in learning practices for students; a change that needs to be carefully managed (Kift, 2009; Quinn et al., 2012). Compared to their high school studies, students are given much more freedom including voluntary participation in learning activities. They can choose how and when they participate. Time Budgets (Quinn & Wedding, 2012) are particularly useful to make explicit student workload on various learning activities in and out of the classroom. Time Budgets capture not only what the students need to do, and when, but also the expectations of the time to be spent on those activities. Time Budgets also can play an important role in the design and development of tertiary courses (subjects). Time Budgets are also a key academic development tool as they help academics shift from thinking about what the teacher does, to thinking about what the student does, a key aspect of the pedagogical change needed (Biggs, 1999).

3.2 Towards blended learning – the creation of the 'Lecturette'

The process of making online media based on the lecture component of the course has been staged as described in Table 1, starting with the usual step of making video recordings of lectures available online for students to access at their convenience.

While lecture theatres are routinely equipped for automated recording of lectures, we deliberately bypassed making the unedited, automated recordings of computer projected lecture content as they did not convey the lecture dynamics, nor whiteboard and demonstration activities, which make the lectures more interactive. Instead, all components of the lectures were video recorded and spliced together with the audio before being made available to students in 2014. These 'Raw' lecture videos still represented minute-for-minute versions of the lectures and were made available on the course website at the end of the week after the scheduled traditional lecture were delivered. These lecture videos were then edited by the academic to remove speech mannerisms, class interruptions, announcements and incidental direction to the class, etc. which typically resulted in the standard 50 minute lecture class being reduced to a typically 45 minute Lecture video.

In 2015 'Lecturettes' were created. Lecturette videos identify and focus only on '3 key points' of each developed traditional lecture slide, are significantly shorter (10.6 ± 2.5 minutes, n = 37) than edited lecture videos (typically 45 minutes). The release of each resource video (lecture and Lecturette) was timed throughout the semester to coincide with traditionally timetabled F2F lectures (e.g. 3 resources per week to replace 3 hours of lecture per week).

Table 1 – Staged roll-out of lecture support

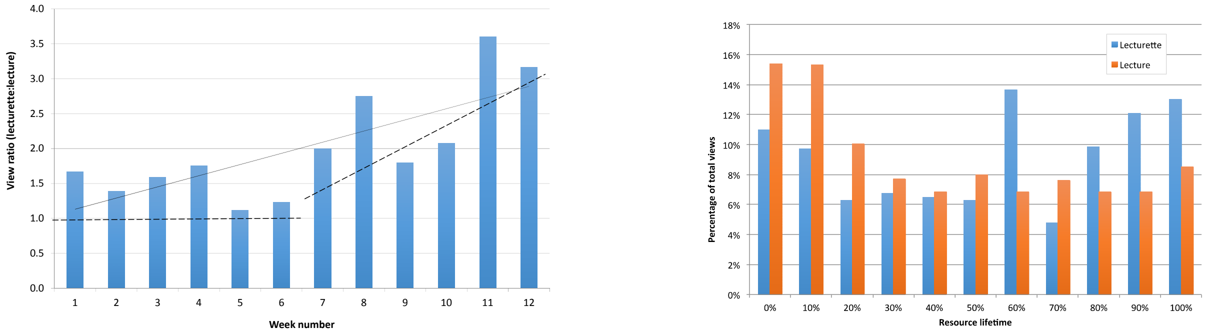
Delivery Component		2013	2014	2015
Lectures				
	Traditional F-2-F	✓	✓	*Flip*
	Lecture Videos		✓*Raw*	✓*Edit*
	Lecturettes			✓
	Tech Talk		✓	✓
Tutorials & Workshops		✓	✓	✓
Practicals		✓	✓	✓

In 2015 the lecture component was also transitioned to a hybrid flipped format. Rather than expose first year students to a dramatically changed learning environment (completely flipped), we proposed a transitional approach whereby F2F lectures were delivered in parallel with the provision of online video resources for the first 4 weeks of the semester. This enables awareness and preparation for the change to online lecture resources and a 1 hour lecture-workshop for weeks 5-13. Based on student feedback from a previous project on the development of a collaborative blended delivery model between universities, (Quinn et al., 2012), the lecture-workshop was provided to guarantee student exposure with the 'expert' (the academic) when flipping the lectures online. The academic is to be open to address student questions and concerns with any aspect of the course, but enables the opportunity to reinforce and elaborate on selected topics from the syllabus. The Lecturettes and lecture-workshops are representative of media to supplement lectures indicated in Figure 1.

Since the online video resources were rolled out over the semester, comparing the number of views per resource may not reveal much information about interaction with the course website throughout the semester (i.e. videos released later in the semester are likely to have fewer views), but it can indicate the relative 'popularity' of lectures vs. Lecturettes for each topic / resource, but in all but two cases, Lecturettes received a greater number of views compared to lecture videos. This indicates a student preference for Lecturettes, which may result from the method of delivery (shorter and more direct), or because these resources were used preferentially as a revision tool leading to the exam.

To understand when students used which online media, the ratio of Lecturette to lecture video views was compared. A trend can be seen (Figure 2(a)), where the students increase their engagement with the Lecturettes for topics covered later in the semester when compared to lecture videos. Again, as this data represents the total number of views across the semester, this may not necessarily indicate that as the semester progressed, the students turned their preference to the Lecturettes, but may be explained by decreased course engagement towards the end of the semester and reliance on more time efficient means to catch up on material prior to the exam.

By taking into account the proportion of total views across the 'lifetime' of resources, student preferences become more apparent (Figure 2(b)).



(a) (b)

Figure 2 – (a) Ratio of lecturette views to lecture video views each week of semester, and (b) averaged proportion of total views across lifetime of resource, comparing viewing trends for lecturettes to lectures.

3.3 Towards flipped classrooms – developing F2F activities

'Tech Talk' sessions, introduced in 2014, are 20 minute interactive sessions at the end of weekly lectures to relate the lecture topics/theory to real world examples and professional practices. An example might be critiquing YouTube videos of jump-starting a car, discussing and analysing the procedure, fault finding in the circuit, relating aspects back to lecture topics, discussing ohmic contacts etc. These helped to improve the relevance of the material being studied.

In 2015, in the modified flipped classroom model, the lecture workshops (weeks 5-13) were also used as opportunities to clarify concepts students had been exposed to through online lectures and Lecturettes.

As described in Table 1 a weekly timetabled F2F Tutorial and a Workshop was offered each year of delivery. The workshops provide learning support and skill development in areas that may not be sufficiently developed before entering tertiary study. The three key areas are: developing a problem solving strategy, development of computer literacy to a level expected in tertiary engineering focussed on professional practices, and group problem solving (how to use study groups); all of which culminate in an exam preparation session. The workshops are voluntary except for on three occasions when the timeslot is used for summative tests. Over the three years of this study (2012-2015) no change in student participation in tutorials and workshops was seen.

The practical component begins with compulsory WH&S, followed by an introductory module providing hands-on experience with instrumentation and measurement, data analysis, and communication expectations, before proceeding to perform a number of experiments linked to the lecture topics. In these latter experiments students are required to analyse data and prepare desktop published reports meeting guidelines from professional bodies, i.e. IEEE/IET. The nature of, and the assessment of the practical component remained unchanged during the period of this study.

3.4 Towards online – developing online activities

F2F tutorials provide a regular two week cycle of 'quiz and conceptual questions' one week, followed by 'quiz feedback and problems' the next week. An abridged list of conceptual questions and numerical problems are selected from the prescribed text for the course and constitute an exercise list made available to students from week 1 of the course. The quizzes consist of typically 7 or 8 multiple choice conceptual questions on the front and a short answer type question with a numerical problem on the back. The quiz is to take 20-25 minutes of the 50 minute class, no more. Similarly the feedback on the quiz is not to consume more than 20-25 minutes of the following tutorial. Over the three years of this study (2013-2015) no change in student participation in tutorial classes was seen. In 2016, online quizzes are being developed to replace paper-based tutorial quizzes in preparation for the first external offering of the course in semester 2, 2016.

3.5 Student satisfaction

Students are asked towards the end of each study period to complete a course evaluation which consists of a number of questions to which they respond using a 5 point Likert scale. The 'overall satisfaction' score for the Engineering Physics N course over the 3 year period of this study is shown in Figure 3, with a relative comparison to the average result for the school, the division and the university as a whole. The shift from F2F to blended mode in 2014 did not appear to change student satisfaction, however the flexibility of the hybrid modified flipped classroom in 2015 was well received.

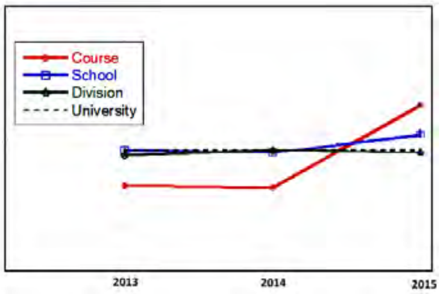


Figure 3: Relative course 'Overall satisfaction' change in relation to the average for all courses in the school, division and university over three years.

3.6 Student outcomes

One measure of the success of a teaching initiative is an improvement is student performance in assessment. Since all other aspects of course delivery were constant, the impact of a partial flipped classroom in 2015 may be appreciated by looking at the grade outcomes. Attempts were made to discern a change in the overall grade or mark distribution year by year, and variations at the individual student level of their overall course grade GPA from their average GPA coming into the course. No statistically meaningful trends or correlations were found within grade levels however there was an overall improvement when considering the % of students whose course grade improved relative to their average GPA grade from 32% in 2014 to 43% in 2015. This is significant considering that the course is considered one of the more challenging in their first year experience. Making incremental changes in delivery results in harder to quantify incremental changes in course marks.

3.7 Student attitudes

To investigate how different students personality types interacted with the flipped classroom, selected students were asked to compete a validated 8-item online quiz to assess grit, a measure of perseverance and passion (Duckworth et al., 2007; Duckworth & Quinn, 2009). Selected distinction and high distinction students all scored a maximum score of 5 in this quiz, which is extremely gritty. Failing students chose not to participate.

4 Conclusion

Individual academics can progressively develop and prepare their engineering courses for student-centred online delivery without the "extreme makeover team" descending upon them. A key first step is to understand their cohort and how to measure and track student workload in and out of the classroom using tools such as Time Budgets (Quinn & Wedding, 2012).

Creating online media such as lecture recordings provide students with a revision tool and enable blended learning. Further refinements, such as the creation of Lecturettes allow key concepts to be concisely presented. Due to the abridged nature of lecturette videos, they are not intended to be a substitute for the full-length lecture videos, but rather a complementary component to lectures and guided readings. Students have flexibility in how they use the Lecturettes, but it is indicated to them that Lecturettes serve as a good starting point for new content, as well as a revision tool prior to summative tests, quizzes, or the end of semester examination.

Engineering students are familiar learning through online videos (Khoo et al., 2015) but data in this study and ours found that they do not fully engage with the required video resources to fully appreciate the body of knowledge which is expected to be covered. Average or struggling students benefit greatly from the viewing of Lecturettes in our hybrid flipped classrooms however credit level students performed less well, perhaps due to over-confidence, that is they may feel that they have already had success in university learning and with all the resources available to them that they can relax and still be successful in the course. Better preparation for this change in learning approach may improve outcomes (Quinn et al., 2012).

Flipping classrooms at university makes students more active and in control (Hamdan et al., 2013). Common themes for development of flipped classrooms include the creation of pre-learning materials (e.g. lecture recordings and Lecturettes), active in-class learning, and revised assessment (McLaughlin et al., 2016). However, introductory courses may not be well suited to flipped classrooms as students have varying incoming foundational knowledge (Strayer, 2012) and it is feared that without 'pedagogical integrity', flipped classroom approaches may 'wither on the vine' (O'Flaherty & Phillips, 2015).

The grittiness of a student has been linked to academic success (Duckworth et al., 2007) but it is not clear how the grit level of students reflects how they engage with blended, flipped and online learning opportunities. Further studies in this area will be incorporated as this course continues to transition towards online delivery.

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Be Smarter Than Your Phone: An Interdisciplinary Educational Approach to Engineering and Innovation

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Abstract: The smart phone has revolutionized the way we communicate and do business. “Be Smarter Than Your Phone”, a three hour, team taught course utilizes the smart phone to demonstrate the multidisciplinary nature of successful innovation and the importance of engineering in our daily lives. It introduces students to the relevant engineering and materials science innovations. This includes an understanding of how the flat panel display, touch screen, battery and semiconductor technologies are combined to make the smart phone possible. It shows how the new capabilities made possible by the smart phone have changed the patterns and nature of our communications. The course explores how the always on, always connected smart phone has brought both power and alienation to the individual and has transformed our entertainment, our politics and our relationships. From a business perspective the course demonstrates how the smart phone led to the demise of companies that failed to innovate and how it is expanding how we shop, bank and sell ourselves and our products. Initially offered as an exploratory, honors course, “Be Smarter Than Your Phone” is being offered to incoming freshman this fall as a gateway to an evolving Innovation Enhancement that can be added to their Bachelor’s Degree at Kent State University. In this expanded role it will reach beyond the smart phone to demonstrate how innovation is always multidisciplinary and how each student, no matter their background or discipline, will be affected by engineering innovations and how they can participate in the innovation ecosystem.

Keywords: Multidisciplinary education, innovation ecosystem,

1. Introduction

We live in an increasingly engineered world. The tempo of innovation continues to increase exponentially. Quoting from the preface to the first volume of “International Perspectives on Engineering Education” edited by Christensen et al (2015), “In such a world, thinking about engineering is increasingly important- and yet increasingly difficult…..there are a host of competing interests that would enroll engineering for their purposes: military interests, nation-building interests, commercial interests, social interests, envirnomental interests and more. Finally, multiple disciplines attempt to take the measure of engineers and engineering: history, sociology, philsophy and more.”

The role of the engineer is rapidly evolving. As noted by Williams (2003) “For most of the 20th century, engineering faculty members assumed that industrial practice depended on students understanding of science’s fundamentals……Today that model is rapidly being displaced by the much more complex interactions of technoscience—a constant process of interaction in interdisciplinary projects where the project, not the disciplines, define the terms of engagement.”

The course, Be Smarter Than Your Phone, is based on Williams' premise that innovation involves much more than the underlying science and technology. It also requires that the innovation be useful and economically sustainable. Indeed it is the end goal, the product and the project that defines the disciplines required for success. The Smartphone provides an excellent example of this premise. The smartphone is indeed a marvel of modern engineering. It combines a host of technologies in a light weight package, Figure 1.

Figure 1: The Smartphone Design

2. The Course

As noted above, the *Be Smarter Than Your Phone* course is intended for first semester freshmen interested in innovation and entrepreneurship with the goal of engaging them in a campus wide innovation ecosystem. It embraces the concept that all students will benefit from an understanding of the multidisciplinary nature of innovation and entrepreneurship, as noted by Edwards-Schachter et al, (2015). It uses the smartphone as a recent and easily relatable technological innovation that clearly demonstrates the multidisciplinary nature of successful innovation. The team taught course blends lectures on technology, communication and business.

Figure 2: The smartphone technologies

Figure 2 summarizes the smartphone technologies. The smartphone is only possible with the recent advances in integrated circuits and displays. It requires sophisticated touchscreens and is pushing the limits of electronic imaging and radio communication. All of these capabilities require the most sophisticated battery technology. Simply managing and balancing the power requirements of each of the components that make the smartphone possible is an engineering marvel.

However impressive are the smartphone technologies, the success of the smartphone is the result of the communication revolution that it made possible. Since its introduction the smartphone has changed the pattern of our daily lives. For today's students their smartphone is their most important possession. They check it when they wake and just before they sleep. It is changing us all. It is changing how we get our news or how we find a date. It keeps us in touch with friends and family. We take store and share our pictures and memories on our smartphones. The myriad of apps available make the smartphone an effective tool, and increasingly indispensable in just about every aspect of our lives.

The smartphone shook up the electronics industry, rewarding those that innovated and adapted to the new order and crushing those that couldn't change, Figure 3. Apple is now the most profitable company in the world. This success is the result of Apple engineering a sleek and powerful device. The success is also the result of their savvy marketing and branding. In contrast Blackberry announced discontinuing their iconic phone in July of 2016. Kodak declared bankruptcy in 2011.

The "Be Smarter than Your Phone" class targets and effectively engages students from all disciplines. They all recognize the utility of the smartphone. Students of the arts or from business

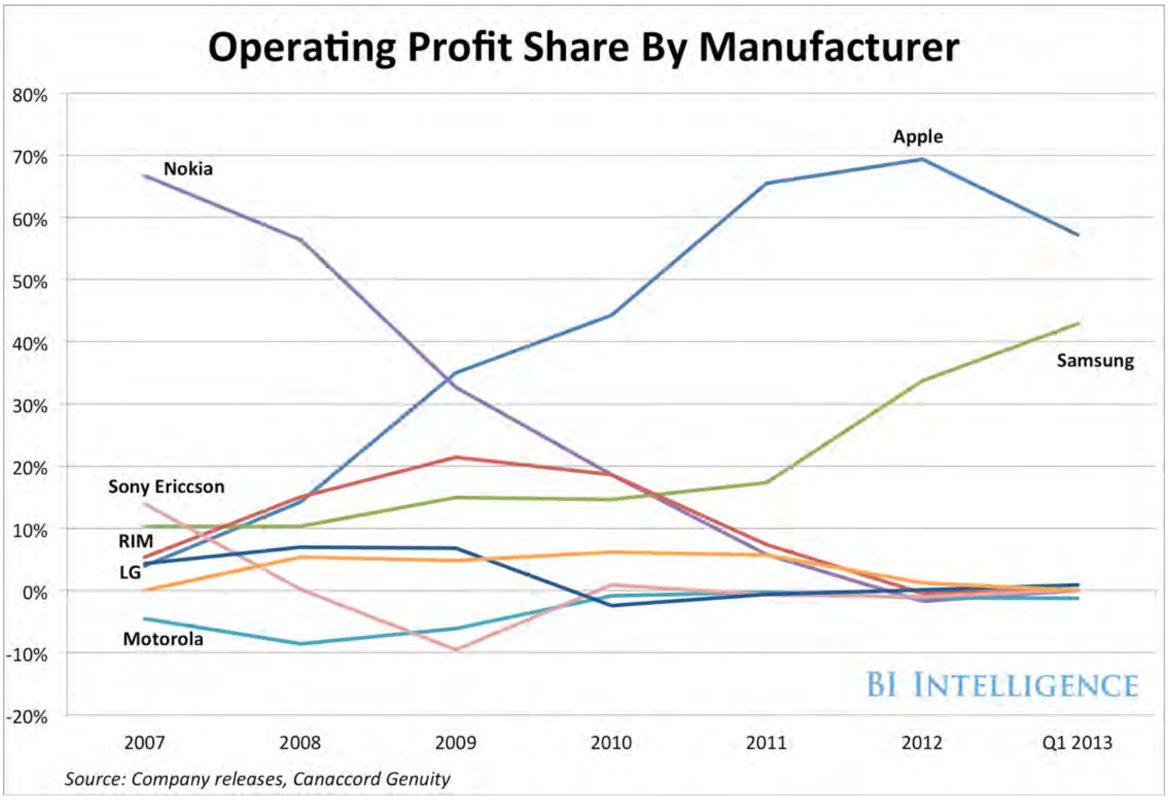

Figure 3: Operating Profits of Cell Phone Manufacturers.

learn the basics of the technologies making the smartphone possible while students with an engineering background learn the communication applications and the business acumen that made the smartphone such a huge success.

The technology and engineering portion of the course highlights the key scientific discoveries and inventions that are the basis of the smartphone industry. It reaches back to the invention of a workable battery and demonstrates how providing a reliable electric current rapidly lead to the discovery of electro-magnetism, the innovation of the telegraph and eventually to the development of radio communication. It uses an understanding of electro-magnetism to explain how a microphone converts an audio to electrical signal and how a speaker reverses the process. It teaches the basic operating principle of the transistor and shows how the development of the integrated circuit also led to an entirely new industry. The student learns about Moore's "Law" and how it relates to the increasingly sophisticated series of products that the exponential growth in computing power has made possible. The student also learns how an analog signal is converted into a digital signal and how digital information is transmitted and stored in a binary format. It then relates this to the practical issues of information storage and transmission. Finally, in this section the students learn the basic concepts of cellular communications.

The communications section of the course introduces students to basic concepts of interpersonal communications and broadcast ing. It discusses how the smartphone is affecting our politics with a focus on the 2016 US presidential campaign. Students will learn how the smartphone has changed our concept of privacy and the extent to which their smartphone activity is monitored and recorded. The communication portion discusses the ever changing role of the smartphone in our daily lives and how its full impact may only be fully understood by the next generation.

The marketing component of the course begins by examining why Apple, despite knowing little about the technology underlying cell phones, led innovation in this realm. We begin by exploring where consumer value stems from, examining the difference between focusing on products rather than solving underlying consumer problems. Understanding the fundamental business a company is in helps students to reframe how firms should be considering their role in society. We then overview Porter's Five Forces in order to give a sense of why some industries are much more competitive (and hence in many cases innovative) than others. This analysis helps understand why existing players in the cell phone market had little incentive to innovate. Following this, we examine Christensen's theory of disruptive innovation, exploring why even if incumbent cell phone manufacturers were motivated to create an innovative smartphone that they would be unlikely to succeed in their attempts. Finally, we end this section by looking more broadly at innovation, discussing both the neat opportunities enabled by the smartphone as well as the challenges involved in getting consumers to trial and embrace innovations.

The course includes visits to local start-up companies that have successfully moved technology from the laboratory to the marketplace. They provide real life examples of how developing the technology is only the first step of successful innovations. The company leaders demonstrate first-hand the importance of working across disciplines and the importance of being able to quickly adapt to meet the needs of their customers and the market.

3. Conclusions:

In the end the course is all about connections. The course takes inspiration from the classic BBC documentary series Connections and the book by the same name, both the inspiration of James Burke (1978). It goes a few steps beyond, taking a much closer look at the complex multidisciplinary connections required for successful innovation. It provides practical support for the importance of a liberal education not only for students of engineering but for all students.

We have designed the Be Smarter Than Your Phone course as a gateway for students to join an evolving Innovation Ecosystem at Kent State University. It exposes students from all disciplines to the essential role engineering plays in innovation but also the importance of how an innovation is applied; how it affects our daily lives. It also makes clear that while all innovations may not require the generation of large profits, they all must be self-sustaining and must be based on a sound business model.

We hope this course will serve as a template for additional courses, focusing on different innovations. It can be easily broken into modules for inclusion in courses from every discipline. It is planned to be integrated into an evolving innovation enhancement to a student’s degree that will also include focused seminars and a capstone project intended to engage the student directly in multidisciplinary teams to bring an innovation to the market.

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Evaluation of the Education System based on the Stratified Sampling Network Method

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Abstract: A new stratified sampling network method is provided to evaluate the performance of education system in this study. The education system is first modelled as a multi-state flow network (MFN) such that each node, arc, and weight are denoted by the evaluation criteria, the relationship among indices, and the impact of the relationship. Then, the proposed stratified sampling network method is implemented to calculate the evaluate the successful index (probability) of the education system which is the reliability of the MFN. In order to demonstrate the technical feasibility and applicability of the proposed method, one example is illustrated to present step-by-step.
Keywords: Education System, performance evaluation, multi-state flow networks (MFN), stratified sampling, binary flow networks (BFN)

1. Introduction

The evaluation of the education system plays an important role in judging the performance and quality of education system. A novel method to evaluate the education system by modelling the system as a MFN of which the successful index (probability) can be defined as the MFN reliability. Many works of reliability theory are devoted to develop various algorithms to solve all kinds of systems. For example, d-MCs (d-minimal cuts) (Yeh, 2004a, 2004b, 2003a, 2003b; Yeh et al, 2015), d-MPs (d-minimal paths) (Yeh, 2005, 2008, 2013, 2015; Huang et al, 2016; Lin, 2010; Lin and Huang, 2013, 2014; Lin et al, 2012; Lin and Yeh, 2011a, 2011b; Niu et al, 2014; Niu and Xu, 2012; Forghani-elahabad and Mahdavi-Amiri, 2015), minimal trees (MTs) (Yeh, 2002), d-MCs with Monte Carlo method (Ramirez-Marquez and Coit, 2007), a Semi-Markov stochastic process and via discrete-event simulation approach (George-Williams, 2016; Ding et al, 2007), dynamic bounding algorithm (Jane and Laih, 2010), Monte Carlo simulation (MCS) (Yeh et al, 2010; Ramirez-Marquez and Rocco, 2009; Schneider et al, 2013; Celli et al, 2013; Fan and Sun, 2010), and universal generating function method (UGFM) (Yeh 2007, 2006; Levitin, 2002; Ramirez-Marquez and Levitin, 2008).
The reliability of multi-state systems is an important index of the system performance, therefore, the accuracy of the reliability what is evaluated is with the relative importance. Generally, the successful probability of the different capacities for each arc in the MFN is given beforehand. Seldom research studies how to obtain the successful probability of the different capacities for each arc in the MFN before evaluating the system's reliability. However, the accuracy of the system's reliability evaluated is influenced by the accuracy of the successful probability of the different capacities for each arc in the MFN. Therefore, this study adapts a stratified sampling method for estimation the successful probability of the different capacities for each arc in the MFN to increase the accuracy of the system's reliability.
The stratified sampling method is by a design to draw the samples from each strata which the populations are stratified by multi-elements in order to lead to major improvements in the accuracy of estimated values (Glasgow, 2005). Hence, the stratified sampling method is adapted by many

works to apply to various fields such as forest cover change (Stehman et al, 2011), heterogeneous data streams (Al-Kateb and Lee, 2014), data splitting (May et al, 2010), the integral allocation problem (Friedrich et al, 2015), data collection (Tripathi, 2011), Energy Dispersive X-ray Fluorescence analysis (Li and Gardner, 2012), optimal allocation (Bretthauer et al, 1999), randomized response model (Christofides, 2005), data clustering (Jing et al, 2015), Ising Model (Streib et al, 2015), relational networks (Li, 2011), execution traces (Pirzadeh et al, 2013), global burned area products (Padilla et al, 2015), and soil microbiology (Wallenius et al, 2011).
The d-MPs is one of the very famous methods to evaluate the reliability of multi-state systems. To the best of the authors' knowledge, no one of these studies has implemented concept of the stratified sampling method to assess the successful probability of different capacities for each arc before evaluating the system's reliability. Hence, this study applies the stratified sampling method to evaluate the system reliability for a MFN by d-MP in order to make improvements in the accuracy of the reliability evaluated.
The rest of this study is organized as follows. Section 2 presents a review of d-MPs. Section 3 provides the stratified sampling method. Section 4 addresses the proposed method. Section 5 has a conclusion.

2. d-MPs

Many studies are devoted to apply and improve d-MPs (d-minimal paths) (Yeh, 2005, 2008, 2013, 2015; Huang et al, 2016; Lin, 2010; Lin and Huang, 2013, 2014; Lin et al, 2012; Lin and Yeh, 2011a, 2011b; Niu et al, 2014; Niu and Xu, 2012; Forghani-elahabad and Mahdavi-Amiri, 2015) to evaluate the system's reliability that is defined as the probability that at least d level of flows can be successfully transmitted from the source node to the sink node in MFN. Yeh (2015) developes a novel node-based technique that makes a great improvement in the time complexity and the storage space to find out all d-MPs in MFN. Therefore, this study apply d-MPs with the node-based technique that is developed by Yeh (2015) to efficiently find out all d-MPs and to evaluate the system's reliability in MFN.
Yeh (2015) proposes the d-MPs with the node-based technique to efficiently find all d-MPs and to evaluate the system's reliability. Fist, if there are total m nodes in the MFN, m equations can be formulated according to the flow conservation law. All d-MP candidates can be easily found by the m equations based the node-based technique with the implicit enumeration method. Second, Yeh (2015) proposes Theorem 1 to verity all d-MP candidates found in Step 1 in order to improve the time complexity and the storage space. For i=1,…,n, let P_i be the real d-MPs verified by Theorem 1. Finally, the system's reliability denoted R_s can be calculated according to the inclusion-exclusion method as shown in Eq.(1).

Theorem 1: A system-state vector X is a d-MP if and only if there is no directed cycle in X.

$$R_s = \sum_i^n \Pr(p_i) - \sum_{j=2}^n \sum_{i=1}^{j-1} \Pr(p_i \cap p_j) + \sum_{j=3}^n \sum_{i=2}^{j-1} \sum_{k=1}^{i-1} \Pr\left(p_i \cap p_j \cap p_k\right) + \cdots + (-1)^{n+1} \Pr(p_1 \cap \ldots \cap p_n) \quad (1)$$

The procedure of d-MPs with the node-based technique is as follows.

Step 1. Find all d-MP candidates by the node-based technique with the implicit enumeration method.
Step 2. Verify the d-MP candidates by Theorem 1 to find all real d-MPs.
Step 3. Evaluate the system's reliability by Eq.(1).

3. Stratified sampling method

The theory for proportionate stratified sampling was developed by the statistician Bowley in 1926 who generated the principle of randomization and the major purpose of the stratified sampling is to realize more accurate estimates (Govindarajulu, 1999).
The stratified sampling method is reviewed as follows. Let N be the population size, it is divided into several homogeneous strata denoted $N_1, N_2, \ldots, N_L$ as addressed in Eq.(2).

$$N = \sum_{i=1}^{L} N_i = N_1 + N_2 + \cdots + N_L \tag{2}$$

The proportion of each strata divided by the population size is denoted W_i and given in Eq.(3).

$$W_i = N_i / N \tag{3}$$

Let n be the sample size, according to the proportional sampling principle as addressed in Eq.(4), the simple random sampling method is adapted in each strata as shown in Eq.(5).

$$w_i = n_i / n = W_i = N_i / N \tag{4}$$

where w_i is the sampling proportion of each strata divided by the sample size
n_i is the sampling size of each strata for $i = 1,2,\ldots,L$

$$n = \sum_{i=1}^{L} n_i = n_1 + n_2 + \cdots + n_L \tag{5}$$

Finally, apply the stratified sampling to probability evaluation for each class in the strata. Let a_i be the number of units in the ith strata of the sample size n_i that belong to class A, the sampling probability denoted p_i is addressed in Eq.(6).

$$p_i = a_i / n_i \tag{6}$$

4. The proposed method

In this study, the stratified sampling is applied to estimate the successful probability of the different capacities for each arc in the MFN before calculating the system reliability using d-MPs. Let N be the population size, i.e., all the population capacities including each edge in the MFN, the population capacities are divided into L homogeneous strata denoted $N_1, N_2, \ldots, N_L$ as addressed in Eq.(2). The number of strata denoted L equal to the number of edges in MFN because it is more homogeneous in the same edge. Then the successful probability of the different capacities for each arc in the MFN can be found by following the stratified sampling method introduced in Section 3
And the procedure of the proposed method is addressed as follows.

Begin.
Input a MFN.
Begin to implement the stratified sampling method.
Step 1. The population capacities are divided into L homogeneous strata, i.e. L edges, denoted $N_1, N_2, \ldots, N_L$ as addressed in Eq.(2)
Step 2. According to the proportional sampling principle as addressed in Eq.(4), the simple random sampling method is adapted in each strata as shown in Eq.(5).
Step 3. The successful probability of the different capacities for each arc in the MFN can be estimated by Eq.(6).
End.

Begin to evaluate the system reliability using d-MPs.
Step 1. Find all d-MP candidates by the node-based technique with the implicit enumeration method.
Step 2. Verify the d-MP candidates by Theorem 1 to find all real d-MPs.
Step 3. Evaluate the system's reliability by Eq.(1).
End.
Output the system reliability.
End.

5. Conclusion

It is always necessary and very important to evaluate the performance of the education system. In this pilot study, the stratified sampling is applied to estimate the successful probability of the education system by considering the education system is a special MFN. Before calculating the successful probability, which is defined as the reliability of a MFN, using d-MPs, the stratified sampling method is proposed to implement to estimate the successful probability of the different capacities for each arc in the MFN to increase the accuracy of the system reliability that is evaluated. For the future study, a numerical example or a real case study can be demonstrated by the proposed method.

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