A journal of the UNESCO International Centre for Engineering Education (UICEE)

UICEE

GLOBAL JOURNAL OF ENGINEERING EDUCATION

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Monash University
Clayton, Melbourne, VIC 3800, Australia

MELBOURNE 2007

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Published by:

UNESCO International Centre for Engineering Education (UICEE)
Monash University, Building 70, Wellington Road, Clayton, Melbourne, VIC 3800, Australia

ISSN 1328-3154

Papers published in the *Global Journal of Engineering Education* (GJEE) have undergone a formal process of peer review.

GLOBAL JOURNAL OF ENGINEERING EDUCATION

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Editorial

I am delighted by being able to write this editorial to this second Issue (regular) of Volume 11 of the Global Journal of Engineering Education (GJEE). Particularly pleasing is the fact that this Issue consists of mostly revised and expanded versions of the UICEE Best Papers presented and awarded at the two most recent international meetings of engineering educators organised by the UICEE. I am referring to the successful *10th UICEE Annual Conference on Engineering Education*, held at Menam Riverside Hotel, Bangkok, Thailand, between 19 and 23 March 2007, and the *11th Baltic Region Seminar on Engineering Education* that was held at Uniquestay Mihkli Hotel in Tallinn, Estonia, between 18 and 20 June 2007.

It should be pointed out that although small in terms of the number of participants, the two events provided excellent environments for academic debates concerning burning issues and important challenges that engineering and technology education faces in the 21st Century.

The Issue also includes one outstanding article by Prof. Harold P. Sjursen of Polytechnic University of New York, USA, the Chairman of the UICEE Academic Advisory Committee, which received the UICEE Best Paper Gold Award at the *10th Baltic Region Seminar on Engineering Education* that was held at the University of Szczecin, Szczecin, Poland, in September 2006.

In this Issue, our readers will find four contributions from staff and students of the UICEE presenting their research efforts. Three of the articles are revised and expanded versions of the best award papers, which demonstrate the quality of the research carried out in the Centre.

On behalf of the UICEE members, staff, students and associates, it is my great honour and privilege to express my sincere gratitude to the authors of the articles included in this Issue for their contribution to the global debates on engineering education and I look forward to their continuos collaboration with the UICEE. I strongly believe that this particular Issue of the GJEE will further stimulate considerable interest, and will become a useful source of information on new and noteworthy research and development efforts in engineering education.

Zenon J. Pudlowski

Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

Issues and Challenges in Engineering Education and the Future Outlook of the Engineering Profession in Australia*

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Australia is presently experiencing a skills shortage in the engineering profession, so much so that this has led to the listing of the specialities of civil, chemical, mining and petroleum engineering on the *Migrant Occupations on Demand List*. This raises concerns and has serious implications for employers of engineers and engineering academics. In this article, the authors attempt to discuss the cause behind this problem and why this is happening in Australia. Raising awareness of the importance of engineering studies in the national education system at the primary, secondary and tertiary levels and promoting engineering as career prospects are crucial steps to remedy the current situation. Australia operates on a fee-based education system to remain competitive in the global education market. However, there are problems with the fee-based system, which is also briefly discussed. The inevitable process of internationalisation and its impact on engineering education in Australia is also presented. A consideration concerning the introduction of a new engineering model, leading to a Masters of Engineering in Australia, to boost the mobility of students and offer internationally recognised qualifications is also carried out in this article. Finally, the authors propose an alternative model, which maybe suitable for the educational market in Australia, to be realised through the establishment of one common or the so-called global engineering curriculum, which can also be used successfully internationally. Such a curriculum would address the issue of offering an internationally recognised programme that is likely to eliminate the need for any recognition and accreditation problems experienced between countries.

INTRODUCTION

There is a general consensus among engineering educators, entrepreneurs, industry and business leaders that engineering education in Australia is in crisis or at least is heading towards this direction. Australia, which has a small population of approximately 20 million inhabitants, is now facing a shortage of professional engineers, which is a cause for serious concern, and the prediction is that this problem will only become worse given the dramatic decline in student enrolment numbers in engineering courses at the university level [1].

An urgent call for more funding to be directed to engineering education is needed in order to address the national skills shortage of professional engineers in Australia. The general perception is that the current government is not investing enough interest and resources in improving the engineering education system in Australia, thus neglecting the future role of this important profession. It is predicted that if the problem with the skills shortage of engineers and the declining student numbers is not resolved, then this could have a directly negative affect on the future

*A revised and expanded version of a paper presented at the *11th Baltic Region Seminar on Engineering Education*, held in Tallinn, Estonia, from 18 to 20 June 2007. This paper was awarded the UICEE Best Paper Diamond (First Grade) Award by popular vote of Seminar participants for the most significant contribution to the field of engineering education.
**As Director of the UICEE, Prof. Z.J. Pudlowski declined to accept the award, which was accepted by Ms D.Q. Nguyen.

economy of Australia because engineers are seen as the creators, innovators, entrepreneurs and key drivers of the economy.

In the following passage, Farrell highlights the important role that engineers play in boosting the economy:

> *Engineers turn knowledge into application. They devise plans, they design products and processes and they deliver results; they are the ultimate doers. Without innovation there is no wealth creation and as a consequence, no economic growth* [1].

Clearly, the preservation and expansion of this profession is vital for the future growth of this nation.

SKILLS SHORTAGE OF ENGINEERS IN AUSTRALIA

Firstly, one has to ask a critical question: why is this happening in Australia?

Presently, in Australia, less than 5% of 24-year old males hold an engineering degree and even lower figures are reported for the opposite gender falling within this same age group. In fact, only six in 1,000 women in this age group have an engineering degree. In comparison, the figures from other developed nations, such as Japan and Finland, are much higher than in Australia [2].

The highest number of undergraduate engineering enrolments in Australia ever recorded was 11,500 in 1997 and this number has been gradually declining [3]. Australia does not appear to be a big player in the mass production and creation of engineering and IT graduates when compared to other populous countries like China or India.

The skills shortage of engineers in Australia could be viewed in two ways, either from an educational or economic perspective.

From an educational perspective, there are a few reasons why Australia is experiencing this skills shortage of engineers. Firstly, the demand and interest for science and mathematics in primary and secondary schools have declined. Without a proper exposure to mathematics and science, which are the fundamentals of engineering education, elementary level students are not expected to fully understand, appreciate or even be aware of what engineering really entails and/or what an engineer really does.

It is obvious that most students, upon the successful completion of their secondary education, are not likely to enrol at the university level in a discipline that they are not familiar with.

Secondly, the declining interest to study engineering at universities among school leavers is not helping the current skills shortage problem. The rapid decline in domestic undergraduate engineering students began in 2001 and the situation will not improve unless significant changes are put in place.

As stated by Hartley,

> *If universities do not give credit or adequate weighting to engineering studies at secondary level, students will not be interested. If there are not enough HECS funded places for engineering Australia doesn't have a hope of overcoming the skills shortage* [4].

The decline is more noticeable in some engineering disciplines, for example, software and telecommunications, and increased in other areas such as civil engineering [5].

When looking at this problem from an economic perspective, the current skills shortage in Australia is mainly due to the resources boom and growth in the construction industry, both locally and internationally. In addition to this, there is a big global demand for engineers around the world, particularly in Asia, the UK and the USA. The shortage of engineers in the areas of civil, chemical, mining and petroleum has resulted in the listing of these engineering professions on the *Migrant Occupations on Demand List* (MODL), which is a list that shows when there is a national shortage of qualified people in a certain profession [3].

Johnston believes that there are a number of contributing factors that are responsible for this downward trend and these include the following:

- Limited perceptions about likely careers in engineering;
- Fear of mathematics;
- Lack of appeal of subject contents, modes of delivery, enthusiasm and base knowledge of teachers [5].

Others believe that students are turning away from engineering programmes because they are now searching *for a broader education and perhaps more choice* [6].

CHANGES IN THE EDUCATION SYSTEM TO ADDRESS THE SHORTAGE CRISIS

To address this issue of skills shortage in engineering, one must first examine the entire Australian educational system starting from the primary to the tertiary level, and identify where the problems are in the structure and then make the necessary changes to encourage and attract more students to enrol in engineering courses at the tertiary level.

Firstly, the problem needs to be examined at the primary and secondary levels. It would appear that there is a lack of mathematics and science taught in the classroom. Therefore, educators must raise the level of mathematics and science subjects being taught at primary and secondary schools. The exposure to such subjects, which are seen as the fundamentals of any engineering degree, is necessary if students are to have any understanding of what engineering is and what engineering entails.

It is believed that the exposure to mathematics and science subjects at an early age would arouse students' curiosity, interest and enthusiasm for mathematics and science subjects. Moreover, it should help students develop the appreciation, understanding, connection and affinity towards engineering for later study, and prepare students for the transition to study engineering at university. It has been considered by some institutions in Australia that lowering the university entry scores of engineering programmes might increase student enrolment numbers and attract a broader selection of students to study engineering.

The authors are not convinced that lowering the score, and hence the standard of engineering, is the best solution to attract students to engineering courses as the highest calibre of students should be attracted to engineering and not just the average students.

At the tertiary level, a major restructuring and revamping of engineering education, in particular the curriculum contents, is urgently needed in Australia to reflect the changes within the current global market. The new curriculum should have less focus on physics but more on biology, less on technical content and more emphasis on humanities, arts and social sciences, and less focus on analysis and more on synthesis [6]. The new education should be broader in scope, and should integrate knowledge from both the natural sciences and the social sciences and humanities [6].

Further, Boger states that: *Clearly the traditional, almost entirely technically based Australian engineering degree must change and is changing* [6].

In addition to all of these new requirements, the new curriculum must also be consistent, unified and harmonised, and be in accordance and comparable with global standards. More importantly, it must be capable of obtaining international recognition. This leads to the discussion of another important issue in this article, namely, the internationalisation of engineering education.

The other alternative in addressing the nation's shortage of engineers as expressed by Sheridan is to rely on qualified overseas engineers, *either onshore through the immigration program or offshore via outsourcing* [3].

The challenge here, of course, is whether the overseas engineers' qualifications meet Australian national standards and if the foreign qualifications are recognised in Australia so that such qualifications would enable overseas educated engineers to practice their profession in Australia. The other critical issue is to overcome the language and cultural barriers experienced by overseas engineers in Australia.

There has been an increase in the number of skilled immigrants obtaining visas in engineering-related fields from 1,012 in 2001-2002 to 2,636 in 2004-2005. However, these immigrants are largely made up of international students who have studied and successfully completed their education (in engineering-related fields) in Australia and applied for a permanent residence status.

Fox suggests that perhaps removing the Higher Education Contribution Scheme (HECS) fees for engineering degrees might be an incentive to encourage more domestic students to study engineering [7]. This definitely would help, but it is not likely to happen in the near future.

WAYS OF ADDRESSING THE SKILLS SHORTAGE CRISIS IN AUSTRALIA

A list of recommendations was formulated by delegates who attended the recent National Engineering, Science and Technology Skills Summit to address the skills crisis in engineering. The list includes the following suggestions:

- *obtaining more timely and robust data to identify Australia's skills capability and future skills needs;*
- *providing greater support for the teaching of maths and science in schools and universities;*
- *providing primary and secondary students with opportunities to interact with engineers and scientists to spark their enthusiasm and to improve awareness of the rewarding careers available – thereby increasing demand for tertiary courses;*
- *coordinating programs of government, community and professional organisations to provide a solid, technical, experience-based resource for teachers and schools across Australia;*

- *increasing the level of support for university students to improve retention rates;*
- *providing increased support for postgraduate courses to ensure that Australia has an appropriate skills base in advanced technical areas;*
- *addressing workplace culture, remuneration and working conditions to encourage retention of technology professionals;*
- *developing programs to assist technical professionals to upgrade their skills or transfer their expertise into alternative industries;*
- *developing programs to encourage science and engineering professionals to broaden their capabilities to facilitate engagement in the education systems;*
- *supporting initiatives to retain skilled professionals in the workforce* [8].

The points raised in the list all share one thing in common: they all make reference to improving and changing the current education system. This may lead to the conclusion that education appears to be the key solution to the addressing the skills shortage problem.

NATIONAL ENROLMENTS IN ENGINEERING PROGRAMMES IN AUSTRALIA

The national enrolment of students in engineering courses in Australia is presented in Figure 1, obtained from Monash University Planning and Statistics [9]. This line graph represents student enrolment numbers by the field of engineering from 2001 to 2005. This figure takes into account the following:

- Age groups from less than 16 to 60 years or more;
- Attendance mode (internal, external and combination);
- Attendance type (full-time and part-time);
- Course type from non-awards to doctorates;
- Course group (undergraduate, postgraduate and higher education research);
- Field of education (engineering);
- Gender (females and males);
- Students' origins (domestic and international);
- All universities and colleges in Australia offering engineering courses.

There are presently engineering programmes offered in over 30 different engineering disciplines by universities and colleges across Australia.

The overall enrolment numbers show that there has been a steady increase in the enrolments of engineering courses from 48,898 in 2001 to 59,417 in 2005 (although domestic undergraduate enrolments decreased).

It would appear that courses covered in *Engineering and Related Technologies* are the top choice among students, even though the enrolments number has slightly fluctuated from previous years, but it still holds the highest number of enrolments (15,439) in 2005. The next most popular choice among students recorded in 2005 is *Mechanical Engineering* (6,067) follow by *Computer Engineering* (5,237), *Civil Engineering* (5,008), *Chemical Engineering* (3,142), *Electrical Engineering* (4,034) and, finally, *Process and Resources Engineering* (not elsewhere classified) (2,045). However, the figures also show that the decline is happening across some engineering disciplines, namely *Engineering and Related Technologies*, *Mechanical Engineering*, *Computer Engineering* and *Electrical Engineering*, when compared to previous years.

THE INTERNATIONALISATION OF ENGINEERING EDUCATION – THE INEVITABLE PROCESS

Internationalisation, otherwise more commonly known as globalisation, is forcing corporations and educational institutions around the world to think and act globally. As the title of this section suggests, internationalisation is inevitable, which means that no country can avoid or bypass this process if they are to be a competitive player in the global market. The effect is real and is felt across all nations. It has already altered the way that people work and conduct business globally. Also, the impact of globalisation has already had a profound affect on the educational sector. It is putting pressure on educational institutions to modernise, revamp and transform educational materials and policies to meet international standards, offer qualifications that are internationally recognised and produce graduates with global potentials. These are some of the immediate challenges facing educational institutions in Australia and overseas today.

Why has the internationalisation of education become a major concern for educational institutions?

Hallak points out that due to the worldwide spread of the labour market, it has had two consequences:

> *Firstly, the need to compare competencies: how can a company compare a diploma? How can it be sure that certain training has instilled a certain skill? Secondly, the race for excellence: the competition between educational institutions is very likely to intensify and promote the search for the best quality* [10].

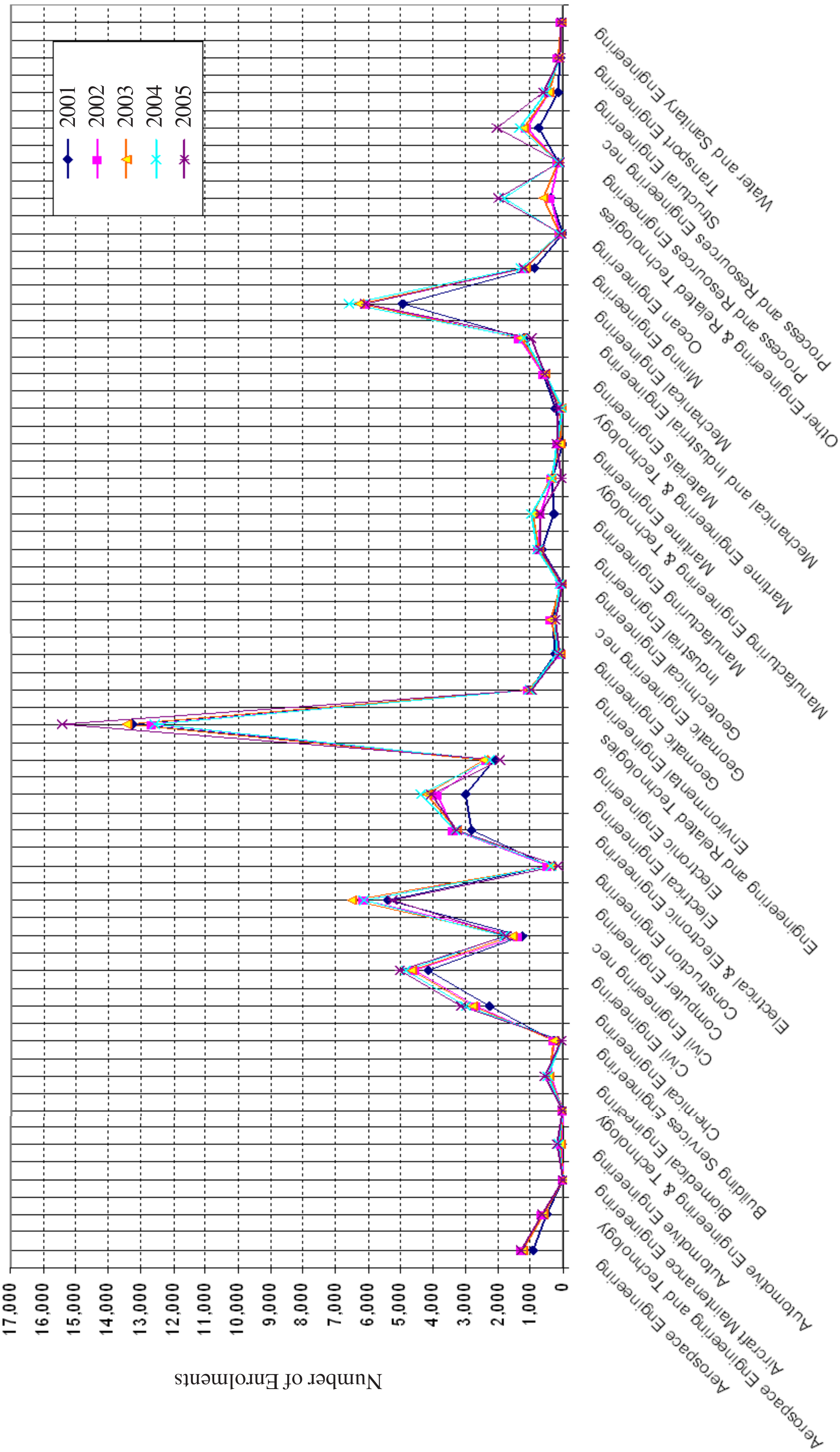

Figure 1: The national enrolment numbers in engineering courses from 2001 to 2005 [9].

Further, Hallak suggests that *the traditional task of higher education in producing the cadres of society should be revised in order to address the new demands and challenges generated by globalisation* [10].

How has this impacted on engineering education in Australia? There have been serious discussions and debates about the problems that arise from the various different standards, accreditation, recognition and diversity of engineering programmes across the globe. These problems would not be an issue if all engineers after graduation would find work and remain making a living in their home countries; but the reality of the problem is that engineering is becoming a global profession due to the impact of globalisation.

Many engineers in Australia are now going off-shore to look for work. This provides a great opportunity for many engineers to gain first hand experience in working overseas. The other obvious reason is that many are forced to travel abroad to seek employment due to the shortages of jobs in the local environment or seek better salaries and job opportunities and prospects. In order to overcome this problem, current engineering education in Australia needs to address the issue of establishing the compatibility, comparability and standardisation of qualifications in education and training systems at the international level. The positive outcome is that engineering education in Australia is already on this path of establishing international accreditation through the Washington Accord and other means.

The impact of internationalisation has influenced many Australian universities to tap into the global market by making their programmes more aligned with those universities in Europe in order to promote student mobility, to be seen as a competitor in the global market, as well as attract full fee-paying Australian students' enrolments [11].

ENGINEERING BECOMING A GLOBAL PROFESSION

Increasingly, engineers conduct their work in more than one country and in countries other than where they received their education. The mobility of students and engineers is very much driven by this process of internationalisation/globalisation. Many countries have different laws, cultures, procedures and standards concerning the education and practice of engineering. It is anticipated that the growth of major trading blocs, such as the European Union (EU), the Asia/Pacific area and the Americas, will intensify this process of mobility. Also, instant worldwide communication is a strong catalyst for the development of the global practice of engineering and engineering education.

It is appropriate for the world's engineering profession to recognise this developing situation and to take steps to ensure the orderly transition into the worldwide practice of engineering, and the education of engineers in particular [12]. Yeargan suggests that one method by which this can be accomplished is through the establishment of international accreditation of engineering educational programmes, the recognition of academic equivalency between institutions, and reciprocal agreements between engineering licensing agencies [12].

ENGINEERING CURRICULA IN AUSTRALIA – A NEW PROGRAMME

The University of Melbourne, which is considered as one of the leading Group of Eight (Go8) universities in Australia, is considering the introduction of a new engineering curriculum leading to a Master of Engineering. The proposed model is similar to that of the European model, which may be undertaken in two stages. The first stage is the undergraduate degree (baccalaureate), which can be completed in three years, followed by a Master's degree that requires another two years (the Bologna Model) so that the total programme is completed in five years. The introduction of this new programme came about because there was a demand for the broadening of engineering education, the lack of mathematics and sciences available at high school, the most obvious reason being to offer a qualification that is internationally recognised, and that the extending the tertiary education process is necessary for Australia to maintain its international standing [13].

The opinions expressed by Evans and Marrels, if other Australian universities were to adopt this very same model of a five-year engineering programme at their institutions, are that this would provide a base for further collaboration among the universities to produce an Australian-wide version of the Bologna-like model. This outcome would increase the flexibility and mobility of students between all Australian universities and perhaps even with European universities.

The ramifications of this shift from four years to five years of undergraduate study for an engineering programme are such that it will eventually replace all bachelor engineering degrees, eliminate double degree programmes in engineering and the standard Master's degree programme either by research or coursework, which is typically completed within two years. The standard Masters programme by coursework remains a popular choice for international students and, hence, a substantial source of revenue for the university.

In fact, the statistics show that the number of students undertaking a Master's degree by coursework grew from 1,022 in 2001 to 2,560 in 2004 and, what is even more surprising, is that more than 80% of the growth was in the field of electrical and electronic engineering [3]. The important question here is: does the introduction of the five-year study programme, leading to a Master's degree in Australia, has a negative impact on this lucrative market? The other question is: does extending the study of engineering to five years deter students from studying engineering and attract them to other disciplines?

PROBLEMS WITH A FEE-BASED EDUCATION SYSTEM

Although there are great benefits and advantages stemming from this new five-year study programme in engineering, the authors are not absolutely certain whether this new model proposed by the University of Melbourne is suitable for the Australian education system, which is predominantly a fee-based education system.

During the most recent years, governments in rich countries, especially in Australia, New Zealand and the UK, have significantly decreased education funding and are forcing many universities to seek private and fee-based funding to remain in operation. In Australia, for example, all universities are charging local students HECS, and hefty educational student fees and charges also apply to international students to obtain a higher degree. The concept of free education was still available in Australia in the early 1980s, but was eventually phased out in 1989 and replaced by fee-based education. The main sources of funding in higher education in Australia are essentially made up of government funding, fees and charges from local and foreign students, as well as HECS.

Australia generates revenue of about $10 billion per year from its education export and attracts a large number of full-fee-paying students, mostly from countries in Asia. The increase in cuts in government educational funding around the world means that commercial and private entities will take a greater role in educational business. Education is slowly becoming a service industry similar to banking, insurance, travel, etc [14]. This seems to be the trend witnessed in recent years in Australia. Fortunately, the situation is not as drastic in those European countries where universities and engineering schools are still receiving large government grants [14]. In light of this situation, the proposed new programme, as advocated by the University of Melbourne, is, perhaps, better suited to cater for higher learning institutions in Europe.

The alternative model strongly advocated by the authors of this article, which maybe suitable for the education market in Australia, is through the establishment of one common or so-called *global engineering curriculum*, which can be used worldwide. Such a curriculum would address the issue of offering an internationally recognised programme, as well as eliminate the need for any recognition and accreditation problems between countries [15].

CONCLUSIONS

Australia is currently facing a skills shortage of domestic engineers across all disciplines. This shortage has come about because of the rapid decline in domestic student enrolments in engineering courses in Australia. The number of enrolments in Australia peaked in 1997 but has declined since. There are a number of contributing factors why students are turning away from engineering. The national curriculum at the primary, secondary and tertiary levels is to blame for this national shortage and changes are urgently needed in the national curriculum to reverse this problem. Moreover, due to the process of internationalisation, Australia is also trying to tap into the global engineering market and offer internationally recognised qualifications and boost student mobility. The University of Melbourne is looking at introducing a five-year programme leading to the Masters of Engineering. The model is similar to that of the European model.

The alternative model, as proposed by the authors, is through the establishment of one common or so-called global engineering curriculum, which would address the issue of offering an internationally recognised programme, as well as eliminate the need for any recognition and accreditation problems between countries. The additional benefits provided by offering a global curriculum have been elaborated on elsewhere [16]. There appears to be general support for the development of the global curriculum in environmental engineering education when taking into account the data collected from an inventory of global engineering educators [16].

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BIOGRAPHIES

Dianne Q. Nguyen graduated with a Bachelor of Applied Science, majoring in chemistry and environmental management, from Deakin University, Australia, in 1994, and then completed her Honours year in 1997 and Masters in Engineering Science (Research) at Monash University, Australia, in 2000.

She has spent time working in research laboratories before entering academia. Since December 1995, she has been with the UNESCO International Centre for Engineering Education (UICEE) in the Faculty of Engineering at Monash University, Melbourne, Australia. She is currently a Research Fellow and finalising her PhD in environmental engineering education.

Her special research interests include environmental engineering, engineering education, sustainable engineering, global education, curriculum analysis and design, statistical analysis, research methods, and women in engineering. Also, she has external interests in Web design and programming in Java and Javascript. In her spare time, she enjoys doing high impact aerobics, weight training, tae-box and reading. Her hobbies include fashion, shopping, computers, travelling, playing music, playing golf and watching movies.

Her awards include: UICEE's *Women in Engineering Education Scholarship* (1997-2000); the UICEE Silver Badge of Honour for her contribution to engineering education and to the operation of the UICEE (1998); the UICEE Best Paper Diamond (First Grade) Award for a distinguished contribution in delivering an outstanding paper to the *Global Congress on Engineering Education* (July 1998); the UICEE Best Paper Silver (Fourth Grade) Award at the *8th Baltic Region Seminar on Engineering Education* (September 2004); the UICEE Best Paper Diamond (First Grade) Award at the *9th UICEE Annual Conference on Engineering Education* (February 2006); the UICEE Best Paper Gold (Third Grade) Award (first place) at the *10th UICEE Annual Conference on Engineering Education* (March 2007); and her latest award, the UICEE Best Paper Diamond (First Grade) Award at the *11th Baltic Region Seminar on Engineering Education* (June 2007). She is also a recipient of the prestigious *Australian Postgraduate Award* (October 2000-October 2003), Monash Departmental Award (October 2000-October 2003) and Monash Travel Grant (October 2001).

She has also served on several national and international engineering education conference organising committees. She has already published close to 50 conference and journal papers.

Ms Nguyen is the current Treasurer of the International Liaison Group on Engineering Education (IL-GEE).

Zenon Jan Pudlowski graduated Master of Electrical Engineering from the Academy of Mining and Metallurgy (Kraków, Poland), and Doctor of Philosophy from Jagiellonian University (Kraków), in 1968 and 1979, respectively.

From 1969 to 1976, he

was a lecturer in the Institute of Technology within the University of Pedagogy (Kraków). Between 1976 and 1979, he was a researcher at the Institute of Vocational Education (Warsaw) and from 1979 to 1981 was an Adjunct Professor at the Institute of Pedogogy within Jagiellonian University. From 1981 to 1993, he was with the Department of Electrical Engineering at The University of Sydney where, in recent years, he was a Senior Lecturer.

He is presently Professor and Director of the UNESCO International Centre for Engineering Education (UICEE) in the Faculty of Engineering at Monash University, Clayton, Melbourne, Australia. He was Associate Dean (Engineering Education) of the Faculty of Engineering between 1994 and 1998.

In 1992, he was instrumental in establishing the International Faculty of Engineering at the Technical University of Lodz, Poland, of which he was the Foundation Dean (1992-1995) and Professor (in absentia) (1992-1999). He was also appointed Honorary Dean of the English Engineering Faculty at the Donetsk National Technical University in the Ukraine in 1995.

His research interests include circuit analysis, electrical machines and apparatus, implementation of computer technology in electrical engineering, software engineering, methodology of engineering education and industrial training, educational psychology and measurement, as well as human aspects of communication in engineering. His achievements to date have been published in books and manuals and in over 350 scientific papers, in refereed journals and conference proceedings.

Professor Pudlowski is a Fellow of the Institution of Engineers, Australia, and of the World Innovation Foundation (WIF), UK. He is a member of the editorial advisory board of the *International Journal of Engineering Education*. He is the founder of the Australasian Association for Engineering Education (AAEE) and the *Australasian Journal of Engineering Education* (AJEE), and was the 1st Vice-President and Executive Director of the AAEE and the Editor-in-Chief of the AJEE since its inception in 1989 until 1997. Currently, he is the Editor-in-Chief of the *Global Journal of Engineering Education* (GJEE) and the *World Transactions on Engineering and Technology Education* (WTE&TE). He was on the editorial boards of the *International Journal of Electrical Engineering Education* (1993-2005) and the *European Journal of Engineering Education* (1993-2005). Prof. Pudlowski was the Foundation Secretary of the International Liaison Group for Engineering Education (ILG-EE) (1989-2006) and is currently its Chairman.

Professor Pudlowski was a member of the UNESCO International Committee on Engineering Education (ICEE) (1992-2000). He has chaired and organised numerous international conferences and meetings. He was the Academic Convener of the *2nd World Conference on Engineering Education*, the General Chairman of the *East-West Congresses on Engineering Education*. He was also General Chairman of the *UNESCO 1995 International Congress of Engineering Deans and Industry Leaders*, and General Chairman of the *Global Congress on Engineering Education*, to name a few.

He received the inaugural AAEE Medal for Distinguished Contributions to Engineering Education (Australasia) in 1991 and was awarded the Order of the Egyptian Syndicate of Engineers for Contributions to the Development of Engineering Education on both National and International Levels in 1994.

In June 1996, Prof. Pudlowski received an honorary doctorate from the Donetsk National Technical University in the Ukraine in recognition of his contributions to international engineering education, and in July 1998, he was awarded an honorary Doctorate of Technology from Glasgow Caledonian University, Glasgow, Scotland, UK. He was elected a member of the Ukrainian Academy of Engineering Sciences in 1997. In 2002, he was awarded the title of an Honorary Professor of Tomsk Polytechnic University, Tomsk, Russia, and was an External Professor at Aalborg University, Aalborg, Denmark (2002-2007). He is listed in 14 *Who's Who* encyclopaedias, including the Marquis *Who's Who in the World*. He has been recently appointed to the Register for External Reviewers of the Oman Accreditation Council (OAC).

11th Baltic Region Seminar on Engineering Education: Seminar Proceedings

edited by Zenon J. Pudlowski

The yearly *11th Baltic Region Seminar on Engineering Education* was organised by the UNESCO International Centre for Engineering Education (UICEE) and held Tallinn, Estonia, between 18 and 20 June 2007. The Seminar attracted participants from 10 countries worldwide. Almost 40 papers have been published in this Volume of Proceedings, which grossly document and present academic contributions to the Seminar. All of these published papers present a diverse scope of important issues that currently affect on engineering and technology education locally, regionally and internationally.

The principal objective of this Seminar was to bring together educators from the Baltic Region to continue dialogue about common problems in engineering and technology education under the umbrella of the UICEE. To consider and debate the impact of globalisation on engineering and technology education within the context of the recent economic changes in the Baltic Region, as well as in relation to the strong revival of the sea economy. Moreover, the other important objectives were to discuss the need for innovation and entrepreneurship in engineering and technology education, and to establish new links and foster existing contacts, collaboration and friendships already established in the region through the leadership of the UICEE.

The papers incorporated in these Proceedings reflect on the international debate regarding the processes and structure of current engineering education. They are grouped under the following broad topics:

- Opening address
- Education and training for engineering entrepreneurship
- Innovation and alternatives in engineering education
- New developments and technologies in engineering education
- Quality issues and improvements in engineering education
- New trends and approaches to engineering education
- Simulation, multimedia and the Internet in engineering education

It should be noted that all of the papers published in this volume have undergone an international formal peer review process, as is the case with all UICEE publications. As such, it is envisaged that these Proceedings will contribute to the international debate in engineering education and become a valuable source of information and reference on research and development in engineering education.

To purchase a copy of the Seminar Proceedings, a cheque for $A70 (+ $A10 for postage within Australia, and $A20 for overseas postage) should be made payable to Monash University - UICEE, and sent to: Administrative Officer, UICEE, Faculty of Engineering, Monash University, Clayton, Victoria 3800, Australia. Please note that sales within Australia incur 10% GST.

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Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

Using Rubrics to Assess the Development of CDIO Syllabus Personal and Professional Skills and Attributes at the 2.x.x Level*

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The Department of Aerospace Engineering at the United States Naval Academy (USNA) in Annapolis, USA, joined the CDIO Initiative (Conceive – Design – Implement – Operate) in July 2003. The US Naval Academy already emphasised many of the skills in the CDIO Syllabus, such as ethics, leadership, teamwork, systems thinking and communications, which are part of design-build projects, integral components of a CDIO programme. What was lacking was the overall framework for developing a curriculum that was consistent with the Department's goals and one that could be used to guide outcomes assessment. The CDIO Syllabus provided that framework. In this article, the authors describe the process of developing and implementing the CDIO Syllabus personal and professional skills and attributes (2.x.x).

INTRODUCTION

The CDIO (Conceive – Design – Implement – Operation) project learning assessment model is based on the principle that product and system lifecycle development and deployment are the context of engineering education. Its mission is to graduate engineers who are able to conceive, design, implement and operate complex, value-added engineering products and systems in modern team-based environments so as to appreciate engineering processes and contribute to the development of engineering products while working in engineering organisations.

As a result, the intended attributes of CDIO graduates include the following:

- Understanding disciplinary fundamentals;
- Understanding design and manufacturing;
- Possessing a multidisciplinary system perspective;
- Exhibiting good communication skills;
- Having high ethical standards [1].

Of course, each CDIO programme develops expected student learning outcomes that are consistent with the programme mission and are validated by programme stakeholders. Typically, programme outcomes include technical knowledge and reasoning, personal and professional skills and attributes, interpersonal skills such as teamwork and communication, and conceiving, designing, implementing and operating systems in the enterprise and societal context.

USNA'S ADOPTION OF CDIO

The Department of Aerospace Engineering at the United States Naval Academy (USNA) in Annapolis, USA, joined the CDIO Initiative in July 2003. The CDIO Initiative provides it with the framework and tools necessary to make and assess changes in the Department's programme. Before describing why and how CDIO was adapted to the programme, it is necessary to understand the mission of the United States Naval Academy, which is as follows:

*A revised and expanded version of a Opening Address presented at the *11th Baltic Region Seminar on Engineering Education*, held in Tallinn, Estonia, from 18 to 20 June 2007. This paper was awarded the UICEE Best Paper Platinum (joint Second Grade with one other paper) Award by popular vote of Seminar participants for the most significant contribution to the field of engineering education.

> *Develop midshipmen morally, mentally and physically and to imbue them with the highest ideals of duty, honor and loyalty in order to provide graduates who are dedicated to a career of naval service and have potential for future development in mind and character to assume the highest responsibilities of command, citizenship and government* [2].

The mission of the Department of Aerospace Engineering must follow from the mission of the Naval Academy, while at the same time emphasising the role of the aerospace engineering major. The Departmental mission and vision are a direct result of its participation in the CDIO Initiative. The Department's mission is to: Provide the Navy and Marine Corps with engineering graduates who are capable of growing to fill engineering, management and leadership roles in the Navy, government and industry, maturing their fascination with air and space systems. The Departmental vision follows this mission: mission fulfilment requires a programme wherein midshipmen Conceive – Design – Implement – Operate complex mission-effective aerospace systems in a modern team-based environment.

The US Naval Academy already emphasises many of the skills in the CDIO Syllabus, such as ethics, leadership, teamwork, systems thinking and communications, which are part of design-build projects, integral components of a CDIO programme [3]. What was lacking was the overall framework for developing a curriculum consistent with Department's goals and one that could be used to guide outcomes assessment. The CDIO Syllabus provided that framework. In this article, the authors describes the process of developing and implementing the CDIO Syllabus personal and professional skills and attributes (2.x.x).

A stakeholder survey was first completed in order to determine the level of understanding desired for each of the CDIO Syllabus topics. Following that, a benchmark survey was completed of the courses to identify where to introduce, teach and use each of the topics in the CDIO Syllabus. In the next step, the Department is evaluating student and programme performance in each of the topics. The focus in 2007 is particularly on personal and professional skills and attributes (2.x.x). In those courses where it has been identified that the 2.x.x topics be taught or used, each faculty member is asked to evaluate a student's performance on the topics by answering a set of questions pertaining to the 2.x.x topics. These questions are applied to course homework, projects, examinations and class participation.

ASSESSMENT USING RUBRICS

A student learning assessment model is used to guide CDIO practice (Figure 1). This model provides an approach to student learning assessment that is based on the CDIO standards and the local programme context. The model may be used at the course, programme or institutional level. It describes four elements of student learning assessment, specifically:

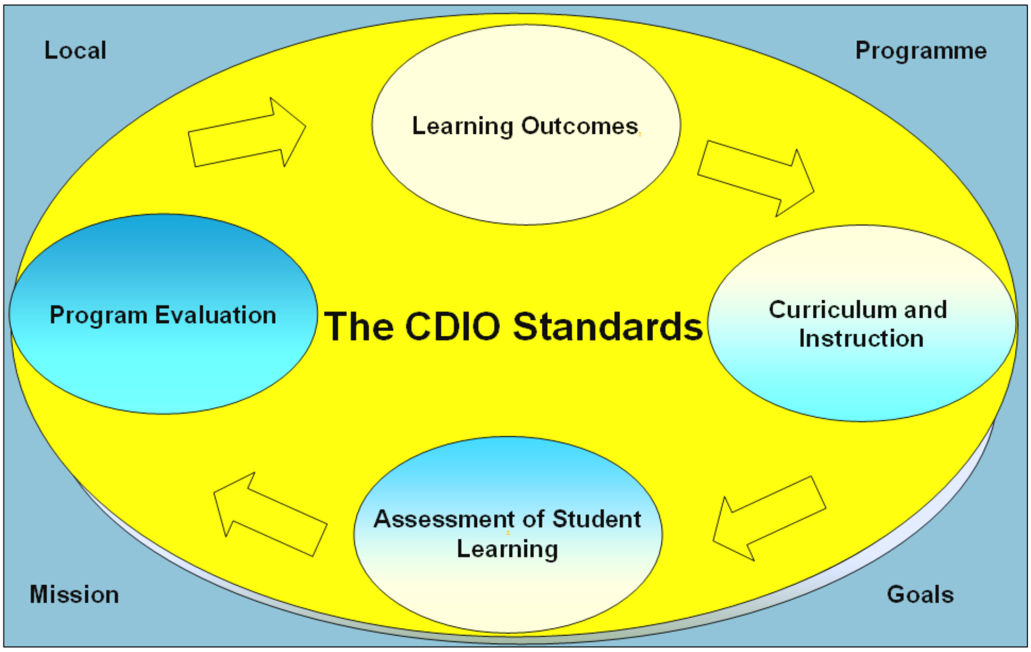

Figure 1: The CDIO student learning assessment model.

- Learning objectives;
- Curriculum and instruction;
- Assessment of student learning;
- Use of assessment results.

The model highlights the importance of aligning teaching, learning and assessment with the CDIO and local programme's intended learning outcomes, as well as the use of assessment results to improve the processes of teaching, learning and assessment.

Assessment requires faculty members to communicate explicit and public statements of learning outcomes and criteria of performance. By doing so, they refine their own understanding of the expected abilities, clarify for their colleagues the basis for their judgements, and enable students to understand what learning and level of performance are required [4].

A CDIO programme uses a variety of evaluation methods to determine whether or not students have acquired the knowledge, skills and values specified in the CDIO Syllabus. The methods available to gather and evaluate student learning include written tests, as well as rating scales (ie rubrics) for evaluating student performance in the form or journals of student reflections, portfolios of student work over time, capstone projects (eg design/build efforts), and oral presentations, in-class discussions and technical reports.

This year, the Department of Aerospace Engineering faculty members focused particularly on the personal and professional skills and attributes (2.x.x in the CDIO Syllabus). In the courses where the teaching or use of the 2.x.x topics had been identified, each faculty member was asked to evaluate a student's performance by answering a set of questions pertaining to the 2.x.x topics in the form of a scoring rubric. Figure 2 shows the criteria for assessment of each of the personal and professional skills and attributes included in the 2.1.x level in the Syllabus.

An example of a rubric developed and field-tested this year is presented in Table 1. This rubric was applied to individual presentations, posters, team presentations, technical reports, laboratory reports, in-class discussion and other artefacts of student performance. The seven syllabus topics with the highest scores from the stakeholder survey were selected and the faculty rated students using the same rating scale utilised in the stakeholder survey. Table 1 shows the data collected for a single course with 13 students. In this course, six of the skills were *used* and one of the skills were *taught*.

The rating scale used to generate the data is the same rating scale that was used in the stakeholder survey. The scoring (1-5) is as follows:

1. To have experienced or been <u>exposed</u> to;
2. To be able to <u>participate</u> in and contribute to;
3. To be able to <u>understand</u> and explain;
4. To be <u>skilled in the practice</u> or implementation of;
5. To be able to lead or <u>innovate</u> in.

The specific CDIO Syllabus 2.x.x topics that were assessed are as follows:

2.1.1 Problem Identification and Formulation;
2.1.2 Modeling;
2.1.3 Estimation and Qualitative Analysis;
2.1.5 Solution and Recommendation;
2.4.2 Perseverance and Flexibility;
2.4.4 Critical Thinking;
2.5.1 Professional Ethics, Integrity, Responsibility Accountability.

2.1 ENGINEERING REASONING AND PROBLEM-SOLVING

2.1.1 Problem Identification and Formulation
Evaluate data and symptoms *Analyse* assumptions and sources of bias *Demonstrate* issue prioritisation in context of overall goals *Formulate* a plan of attack (incorporating model, analytical and numerical solutions, qualitative analysis, experimentation and consideration of uncertainty)
2.1.2 Modelling
Identify assumptions to simplify complex systems and environment *Choose* and *apply* conceptual and qualitative models *Choose* and *apply* quantitative models and simulations
2.1.3 Estimation and Qualitative Analysis
Estimate orders of magnitude, bounds and trends *Apply* tests for consistency and errors (limits, units, etc.) *Explain* the generalisation of analytical solutions
2.1.4 Analysis with Uncertainty
Question incomplete and ambiguous information *Interpret* probabilistic and statistical models of events and sequences *Interpret* engineering cost-benefit and risk analysis *Discuss* decision analysis *Identify* margins and reserve
2.1.5 Solution and Recommendation
Select problem solutions from among candidates *Analyse* essential results of solutions and test data *Analyse* and *reconcile* discrepancies in results *Choose* summary recommendations *Appraise* possible improvements in the problem-solving process

Figure 2: Personal and professional skills and attributes.

Table 1: Assessment data for a single course and 13 students.

2.1.1	2.1.2	2.1.3	2.1.5	2.4.2	2.4.4	2.5.1
Use	Use	Use	Use	Use	Teach	Use
2	1	3	3	2	1	4
3	3	3	3	3	3	4
2	1	3	3	2	3	4
3	3	3	2	3	2	4
3	3	3	3	2	2	4
3	3	3	4	3	3	4
3	3	3	3	3	3	4
3	3	3	4	3	4	4
3	3	3	4	4	4	4
3	3	3	4	4	4	4
3	3	3	3	3	3	4
3	3	3	3	4	4	4
2	1	2	2	3	3	4

LESSONS LEARNED AND NEXT STEPS

Of all the syllabus topics, the personal and professional skills and attributes (2.x.x syllabus topics) appear to be the most difficult to measure and the most subjective. The task seemed overwhelming until it was decided to reduce the number of skills to be assessed. Table 1 presents the results from one course with 13 students. Based on the curriculum benchmark results, the only CDIO skill taught in this course was 2.4.4: Critical Thinking. The other CDIO skills used in this rubric were used in the course and observed by the instructor, but not necessarily taught in the course.

Ratings for the courses are shown in Table 2 and Figure 3. The data are the average values for each CDIO skill for each year group. The last line of the table and the last column for each skill in the figure show the goal for each skill. This goal is based on the input for the stakeholder's survey using the same rating scale.

The data shown in Table 2 and Figure 3 indicate improvements in all of the topics from the 2nd year to the 4th year. These data represent a snapshot of the programme at the end of the spring 2007 semester and is not longitudinal data. In other words, the students evaluated in the 2nd year are not the same students evaluated in the 3rd and 4th years, but rather the data represent where students were assessed in each of the year groups at that time.

Also, the data indicate that the Department is close to, or meeting, the objective in six of the seven skills. The skill where the assessment falls short of the desired level based from the stakeholder survey is 2.1.1: Problem Identification and Formulation. In order to improve students' problem-solving skills, a standard problem-solving handout has been introduced to students in their 2nd year and all faculty members are being encouraged to use the handout in subsequent courses in the programme.

Finally, a separate assessment tool indicates that students' critical thinking skills (CDIO Syllabus Topic 2.2.4) are not at the level desired. To improve their critical thinking skills, a Critical Thinking Workshop

Table 2: Assessment data for 2007.

Year	2.1.1	2.1.2	2.1.3	2.1.5	2.4.2	2.4.4	2.5.1
2nd year	2.79	2.89	2.73	2.72	3.08	2.88	3.34
3rd year	2.56	2.75	2.77	2.60	3.26	2.81	3.42
4th year	3.23	3.35	3.32	3.39	3.40	3.35	3.52
Goal	4.1	3.2	3.6	3.6	3.3	3.6	3.7

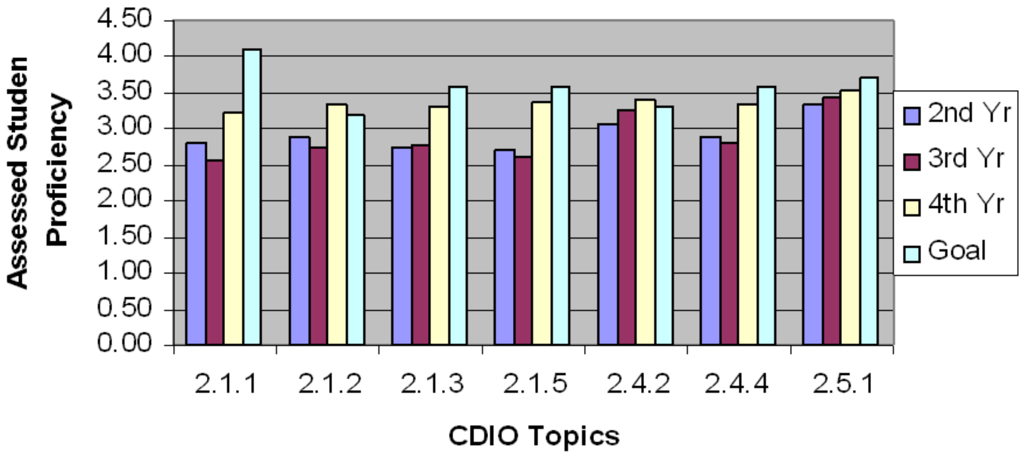

Figure 3: USNA assessment of CDIO 2.x.x topics.

was introduced for those students in their 2nd year. This workshop provides students and faculty members with a standard language for evaluating student work. Again, faculty members are encouraged to use this language in subsequent courses.

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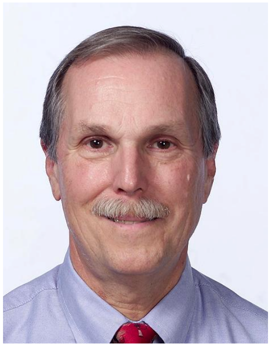
BIOGRAPHIES

Prof. Boden earned his PhD in aeronautical and astronautical engineering from the University of Illinois in 1986. His educational focus was on astronautics, particularly orbit determination and estimation. He served for 20 years in the United States Air Force and retired as a Lt. Colonel in 1993. While on active duty in the Air Force, he taught in the Department of Astronautics at the United States Air Force Academy from 1980 to 1993.

Following retirement from the Air Force, he moved to the United States Naval Academy where he has been a member of the faculty since 1997. While a member of the Aerospace Engineering Department, he has served as the Director of Astronautics and the Department Chair. Dr Boden edited the book, *Cost-Effective Space Mission Operations*, and authored several chapters in books in the Space Technology Series. Recently, he has authored several papers detailing the US Naval Academy's participation in the Conceive – Design – Implement – Operate (CDIO) project and he has conducted numerous CDIO workshops around the world.



Dr Gray earned his PhD in educational psychology from the University of Oregon and his Masters degree in curriculum theory from Cornell University. His areas of higher education expertise include student learning outcomes assessment; evaluation and research methodology; institutional effectiveness and quality assurance; course, curriculum and programme design, development and evaluation; and leadership and planned change.

From 1984 to 2002, he was the Associate Director of the Syracuse University Center for the Support of Teaching and Learning. He became the Director of Academic Assessment at the United States Naval Academy in August 2002, where he is responsible for developing and maintaining a broad programme of academic assessment.

Dr Gray has over 40 publications including the chapter Roots of Assessment: Tensions, Solutions, and Research Directions in *Building a Scholarship of Assessment* (Banta, editor, 2002) and Viewing Assessment as an Innovation: Leadership and the Change Process in *The Campus-Level Impact of Assessment: Progress, Problems, and Possibilities. New Directions in Higher Education* (number 100, winter 1997, co-edited with Banta). Dr Gray chaired the Middle States Association Commission on the Higher Education Advisory Panel on Student Learning and Assessment that produced the publication, *Student Learning Assessment: Options and Resources*. He has also given approximately 100 workshops, keynote addresses and presentations at conferences and on individual campus worldwide concerning topics related to the enhancement of higher education excellence.

Conference Proceedings of the *10th UICEE Annual Conference on Engineering Education* under the theme: *Reinforcing Partnerships in Engineering Education*

edited by Zenon J. Pudlowski

The *10th UICEE Annual Conference on Engineering Education*, held under the theme of *Reinforcing Partnerships in Engineering Education*, was organised by the UNESCO International Centre for Engineering Education (UICEE) and was staged in Bangkok, Thailand, between 19 and 23 March 2007, at the Menam Riverside Hotel.

This volume of Proceedings covers a wide selection of various papers submitted to this Conference, which detail a range of important international approaches to engineering education research and development related to the Conference theme, as well as other specific activities.

The 64 published papers from authors representing 25 countries offer an excellent collection that focus on fundamental issues, concepts and the achievements of individual researchers. The papers have been organised into the following sections:

- Opening Addresses
- Keynote Addresses
- Innovation and alternatives in engineering education
- New approaches to engineering education
- International examples of engineering education and training
- Current issues and trends in engineering education
- UICEE Special Session
- Multimedia and the Internet in engineering education
- Important issues and challenges in engineering education
- Case studies
- Effective methods in engineering education
- Quality issues and improvements in engineering education
- Research and development activities in engineering education at the ECUST

The diversity of subjects, concepts, ideas and international backgrounds in this volume of Proceedings demonstrate the global nature of UICEE-run Conferences, as well as its relevance within the worldwide affairs regarding engineering and technology education.

Importantly, all of the papers have undergone assessment by independent international peer referees and have been professionally edited in order to ensure the high quality and value of the Proceedings into the future. As such, it is anticipated that this volume will become a useful source of information on research and development activities in the dynamic and evolving field of engineering and technology education.

In order to purchase a copy of the Proceedings, a cheque for $A100 (+ $A10 for postage within Australia, and $A20 for overseas postage) should be made payable to Monash University - UICEE, and sent to: Administrative Officer, UICEE, Faculty of Engineering, Monash University, Clayton, Victoria 3800, Australia. Tel: +61 3 990-54977 Fax: +61 3 990-51547

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Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

Scenario-Based Learning and Assessment for Second Year Aviation Students*

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The aviation courses, *Navigation and Flight Planning 1* and *Navigation and Flight Planning 2*, offered in the Bachelor of Applied Science (Civil Aviation) at the University of South Australia (UniSA), Adelaide, Australia, provide the aeronautical knowledge requirements of five of the eight Civil Aviation Safety Authority's Air Transport Pilot Licence Examinations. Although scenario-based learning has been used for a number of years in these courses, scenario-based assessment has not been used until recently. In previous years, the final assessment of student learning was mediated by way of examination. This allowed an assessment of critical aspects of aviation education – speed and accuracy. However, there is a question as to whether the examination accurately assessed the level of student learning in all areas of the syllabus, especially given the amount of material to be learned. To this end, this project investigated a compromise assessment, the one-day scenario-based assignment. This was hypothesised to both assess a student's level of learning in a larger proportion of the course and impose some requirements for the assessment of speed and accuracy. The author discusses the results of this project in this article.

INTRODUCTION

It is vitally important for a pilot to have the ability to accurately flight plan. One of the most important functions of flight planning (if not the most important function) is the calculation of the minimum flight fuel required for the flight. Failure to accurately calculate the flight fuel could very well result in an aircraft running out of fuel with the potential for a large loss of life.

Since 1 January 1983, the National Transportation Safety Board (NTSB) in Australia has maintained a national database of aviation accident and incident reports. An analysis of the NTSB's database from 1 January 1983 to 31 May 1998 has revealed that about one in five accidents are caused by a fuel-related event. The majority of these accidents were precipitated by an in-flight fuel crisis event. Almost all of these in-flight fuel crisis events resulted in a loss of engine power in one or more engines. Investigation has shown that these in-flight fuel crisis events were predominantly caused by pilot error, with only a small fraction being attributed to mechanical failure of the engine or fuel system. These events are significant because they resulted in an estimated 2,000 fatalities over the 14-year period [1].

Perhaps alarmingly, in 43% of these events, the pilot ran out of fuel (fuel exhaustion). Of these fuel exhaustion events, 28% were due to lack of proper flight planning on the ground before take-off (pre-flight planning) and 28% were due to lack of proper in-flight planning (loss of fuel situation awareness) (see Table 1). Therefore, some 56% of the fuel exhaustion events were directly attributable to poor understanding of flight planning and the calculation of flight fuel required for the flight. In fact, some pilots did not undertake any flight planning; relying on previous experience instead [2]. This neglect obviously demonstrates a very poor flight planning ability and perhaps a fear of the complexities and difficulties of the flight planning process.

*A revised and expanded version of a paper presented at the *11th Baltic Region Seminar on Engineering Education*, held in Tallinn, Estonia, from 18 to 20 June 2007. This paper was awarded the UICEE Best Paper Platinum (joint Second Grade with one other paper) Award by popular vote of Seminar participants for the most significant contribution to the field of engineering education.

Table 1: Summarised root causes of fuel exhaustion precipitated in-flight fuel crisis events.

Root Causes of Fuel Exhaustion	Proportion
No accurate fuel check	42%
Loss of fuel situational awareness	28%
Inaccurate pre-flight fuel plan	28%
Flying under the influence of alcohol	1%
Mechanical	1%
Lack of fuel system knowledge	1%

Therefore, it is worthwhile examining any educational methodology that has the potential to improve a student's understanding of flight planning as it could significantly reduce the probability of accidents and their associated loss of life.

In this article, the author introduces the Bachelor of Applied Science (Civil Aviation) (the aviation degree) offered by the University of South Australia in Adelaide, Australia, and describes a scenario-based approach to the teaching and learning of complex flight planning in the second year of the aviation degree programme.

AVIATION DEGREE PROGRAMME

The aim of the Bachelor of Applied Science (Civil Aviation) is to prepare graduates for a career as a professional airline pilot. The degree meets the academic requirements of the relevant professional and regulatory bodies for recognition as an air pilot. The first year of the degree includes aeronautical courses up to the Commercial Pilot Licence level and includes courses in aerodynamics and aircraft systems, navigation and meteorology, aviation legislation and procedures, and flight planning and aircraft performance. The second year of the degree focuses on the aeronautical knowledge required to hold an Air Transport Pilot Licence. Courses in the second year include aerodynamics and aircraft systems, navigation and flight planning, human factors and meteorology.

Historically, students have found the second year aviation courses *Navigation and Flight Planning 1* and *Navigation and Flight Planning 2* extremely difficult; especially the latter. Student feedback through the Course Evaluation Instrument (CEI) has revealed that this is generally because the required knowledge base is large and difficult to comprehend. The CEIs also revealed that students regarded the workload as excessive for these courses when compared to the other courses in the second year of the programme. However, they did generally acknowledge that the workload was necessary for a proper understanding of the material. They also accepted that the knowledge and experience gained in these courses are essential for their future airline careers.

The course *Navigation and Flight Planning 2* requires an in-depth knowledge of navigation, flight planning, flight rules and procedures, instrument flying, aircraft performance, meteorology and aerodynamics. In fact, in this course, the student applies the knowledge gained in all of the courses studied up to this stage in the aviation degree programme. It is this holistic nature of the course that causes some concern to be expressed by students in the CEIs about the magnitude of the workload required by this course when compared to other courses in the second year of the Bachelor of Applied Science (Civil Aviation). Together, these courses provide the aeronautical knowledge requirements of five of the eight Civil Aviation Safety Authority's Air Transport Pilot Licence Examinations.

Managing student expectations, as expressed in the CEIs and the Student Evaluation of Teaching (SETs) is a crucial part of the learning process, and has stimulated the trial and subsequent introduction of scenario-based learning and assessment in these courses.

COURSE STRUCTURE

The aim of the second year *Navigation and Flight Planning* courses is:

> *To provide the student with an understanding of global navigation charts, time zones, the knowledge to operate an aircraft under instrument flight rules; a knowledge of jet aircraft performance data and the additional knowledge and skills to enable planning and navigation of international flights using advanced flight planning techniques.*

The learning objectives for these courses are such that at the end of the second year, a student should be able to:

- Determine potential hazardous weather conditions;
- Plan an IFR flight following the correct departure, cruise and approach procedures;
- Explain the operation and limitations of radio navigation aids;
- Explain the types of navigation and aeronautical charts used on international flights;
- Convert global time zones to UTC, LMT, LST for any part of the world;
- Explain the altimetry procedures used on international flights;

- Describe and explain the procedure following an engine failure in flight in a multi-engine aeroplane;
- Interpret an instrument approach procedure from an instrument approach plate;
- Interpret an instrument departure procedure from an instrument departure plate;
- Explain and demonstrate advanced navigation and flight planning techniques for a path between two specified points in either hemisphere;
- Explain the use of visual, radio and instrument navigation techniques for both day and night flights;
- Calculate the maximum operating weight and corresponding speeds and levels for all stages of flight, using specimen performance graphs and charts.

In addition, there are University-defined Graduate Qualities that a student is expected to develop while undertaking these courses, and the programme as a whole. These are as follows:

1. *operates effectively with and upon a body of knowledge of sufficient depth to begin professional practice*
2. *is prepared for life-long learning in pursuit of personal development and excellence in professional practice*
3. *is an effective problem solver, capable of applying logical, critical, and creative thinking to a range of problems*
4. *can work both autonomously and collaboratively as a professional*
5. *is committed to ethical action and social responsibility as a professional and citizen*
6. *communicates effectively in professional practice and as a member of the community*
7. *demonstrates international perspectives as a professional and as a citizen* [3].

The essential topics covered in these courses include the following:

- Navigation techniques;
- Point of safe diversion;
- Point of equal time;
- Point of equal fuel;
- Route navigation;
- Flight progress charts;
- The compilation of long distance flight plans;
- Aircraft performance and methods of cruise control;
- The use of aircraft performance data, charts and graphs;
- Weight and balance, and the compilation of load and trim sheets.

Once a student has understood the fundamental techniques of flight planning, which is explained and presented as a body of knowledge in *Navigation and Flight Planning 1* and the first one third of *Navigation and Flight Planning 2*, a student is able to tackle real world situations and the problems associated with them. That is, the student is able to study a real situation involving a heavy jet passenger transport aircraft and then solve the flight planning problems associated with that situation. This will involve studying the weather at departure, destination and en route, studying the aerodrome runway distances, calculating the take-off, landing, climb, cruise and descent performance of the aircraft, and calculating the appropriate weight and balance of the aircraft; that is the loading of payload, including passengers.

Analysis of real world problems, especially those of a holistic nature, have a tendency to encourage self-directed learning and help develop professional piloting skills necessary for a student's future career. Thus, the further development of student learning within the course lends itself naturally to student-centred learning strategies. Further, it is generally accepted that to function efficiently in the complex aviation environment, it is essential to have developed sound flight planning skills. This will only occur through intensive practice involving real world situations and their associated problems.

Problem-based learning has been implemented widely in the engineering education domain especially in the area of student projects. Examples of this include Thomas, Hadgraft and Daly [4], Moesby [5], Vandebona and Attard [6] and Perfect, Kendrick, Armstrong and Lockett [7].

The benefits of experiential learning has also been discussed by McDermott, Nedic, Nafalski and Machotka [8]. They argue that student motivation for learning is increased by engaging the student in small project-based exercises.

The author has proposed Crew-Centred Flight Training (CCFT) as a team-based development of student-centred learning. This technique also uses a problem-based learning approach [9].

FLIGHT PLANNING TECHNIQUE

The flight planning technique is explained in detail in a previous paper (see ref. [10]). Briefly, the process involves an iterative technique where the flight fuel is calculated a number of times, each time to a higher degree of accuracy. The reason an iterative approach is used for flight planning is because the rate at which fuel is consumed by an aircraft depends on the weight of the aircraft. Equally, the weight of the aircraft at a particular point on its flight path depends on the rate at which fuel has been consumed. Thus, the weight of the aircraft is dependent on the fuel consumption and the fuel consumption is dependent on the weight of the aircraft. This type of recursive problem indicates an iterative solution.

The iterative solution is usually started by making an estimation of the flight fuel required for the flight. This, together with the payload, determines an aircraft weight at take-off or landing. The flight plan is calculated using one of these weights and at the end of the flight plan, a new value for the flight fuel is determined. From this value of the flight fuel, a new start weight can be calculated and the flight plan worked again to derive another value for the flight fuel. The iteration continues until the difference in flight fuel between successive iterations is within 100 kg.

Mathematically, this is explained below.

Essentially, the weight of a turbine powered aircraft (W) determines the rate at which it consumes fuel (dF/dt). As the weight of the aircraft (W) decreases in flight, the lift, and hence the drag required to maintain altitude, decreases and therefore the aircraft consumes fuel at a lesser rate. Therefore, dF/dt is a function of W. Given that the flight fuel on board the aircraft can be as much as one third of the take-off weight of the aircraft, the weight of the aircraft (W) can change significantly during flight. Therefore, dF/dt will change significantly during flight.

Students use performance tables or charts to determine the rate of fuel consumption at a particular altitude, true airspeed and weight. Using the selected true airspeed of the aircraft and the wind direction (headwind or tailwind) the student can calculate a ground speed and time to arrival at the destination aerodrome (T). The fuel consumption rate, C, given by:

$$C = dF/dt$$

This can be used to calculate the flight fuel (F):

$$F = \int_0^T C\, dt$$

Therefore, as F is a function of C, W is also a function of C.

Therefore, from the above:

$$C = f(W),$$
$$W = f(C)$$

This situation lends itself to an iterative solution where an estimate of W, $W(0)$, can be used to calculate $C(i)$, and $C(i)$ can be used to calculate $W(i)$. The iteration stops when the error, $\varepsilon = (W_{i+1} - W_i)$ is within a prescribed amount.

The manual technique is implemented as follows.

An estimate of the flight fuel can be made giving consideration to the weather, altitude and temperature. The weight of fuel can then be added to the payload weight and the empty weight of the aircraft. This combined weight is the take-off weight of the aircraft. The take-off weight is then checked against the performance and structural take-off weight limits, and if the weight of the aircraft is less than either of these limits, the aircraft can take-off. Otherwise, the weight will have to be reduced by off loading payload until the take-off weight is equal to the limiting weight. A similar process can be followed for the landing weight. In order to keep the effect of weather constant, the flight is normally divided into zones which have approximately constant weather. An average aircraft weight can be calculated for each zone (estimated mid-zone weight) using either the start zone weight or end zone weight. The estimated mid zone weight can then be used to calculated the average consumption rate, $\hat{C}$. The ground speed can then be calculated from the true air speed and the wind effect. Given the distance in the zone the ground speed can be used to calculate the time to fly across the zone, T. The flight fuel for zone j, F_j, can be calculated from:

$$F_j = \hat{C}_j\, T_j$$

This is then repeated for all the flight zones. If there are Z flight zones, the total flight fuel for the i^{th} iteration is given by:

$$F(i) = \sum_{j=1}^{Z} \hat{C}_j(i) T_j(i)$$

The flight fuel, $F(i)$, can then used to calculate the take-off weight or landing weight of the aircraft, $W(i)$, and if the error ε is low, the iteration is stopped and take-off and landing weights checked to see if they are still less than or equal to the performance limits for the runways or the structural limits of the aircraft. If the take-off weight and landing weight are within these limits, the flight is entered on to the flight plan.

For practical purposes, especially when doing the flight plan manually, the iteration is stopped after the second iteration. However, in order for this to occur, an accurate initial flight fuel estimate, $F(0)$, is required to produce an initial estimate of $W(0)$ for either the take-off weight or the landing weight.

SCENARIO-BASED LEARNING

Once the fundamentals of flight planning are learnt and understood by the student in the first course, *Navigation and Flight Planning 1*, the student is exposed to real flight planning problems. For example,

> *You are en route from Melbourne (YMML) to Perth (YPPH) via Q58/J68. By ONS at 2210UTC, your position was on track and 739nm from YMML. This was a positive fix. Your Gross Weight at this time was 76,200 kg and you were cruising at Flight Level 310 at Mach 0.82. At 2225UTC, the no.2 engine was shut down due to low oil pressure. You decide to continue the flight to YPPH as it is a suitable aerodrome. What is the minimum fuel required at the positive fix to proceed to YPPH (including all mandatory fuel reserves)?*

Or:

> *You are en route from Sydney (YSSY) to Adelaide (YPAD) via H36. At Swan Hill (SWH), Air Traffic Control advise that you will be required to hold at Tailem Bend (TBD) at Flight Level 270 (FL270) for 20 minutes for traffic sequencing. In-flight data is SWH FL 310; Mach 0.8; Gross Weight 73,800 kg; wind 300°M/50kts; temperature -35°C. Forecast temperature at FL270 is -27°C. For the purposes of this calculation, the intermediate descent from FL 310 to FL 270 may be ignored. What is the expected average fuel flow and True Airspeed (TAS) while in the holding pattern?*

The weather is given to the student in the same format as it would be in a real situation.

Students are guided through examples of these types of problems in class. Students are also given numerous problems to practice and to solve in their own time. They can also create their own versions of these types of problems if they require more practice.

When students have covered a sufficient number of these elemental problems, which examine all aspects of the aircraft's flight performance envelope, the holistic scenario is introduced.

The holistic scenario is based on a complete flight scenario from the pre-flight briefing, to gathering weather and safety information (see Figures 1, 2 and 3), to loading the aircraft with payload and passengers (see Figure 4), to determining the route and flight levels to fly (see Figure 5), to calculating the fuel required for flight and emergency situations, to calculating the speed, heading and time intervals.

This involves a student processing a vast amount of information in an individualistic way with the intention of planning a safe and revenue-efficient flight. Given the large number of variables in each scenario, each flight plan is unique to the individual student. However, each flight plan is approximately similar within an acceptable envelope of variation.

Anecdotally, there is evidence that student learning is improved by using the holistic scenario-based method for teaching and learning. Students are more actively engaged in the learning experience and become more enthusiastic about solving real flight planning scenarios.

However, some students fail to adequately understand some of the individual elements of the flight planning technique and struggle with this methodology. Other students appear to understand the individual elements or problems but are unable to see the big picture and put all the individual elements together to form a larger problem or scenario. But on the whole, approximately two thirds of the class adapt well to the scenario-based approach.

SCENARIO-BASED ASSESSMENT

Since the primary method of teaching and learning in the course is scenario-based, it seemed reasonable to infer that a scenario-based assessment would more accurately and effectively determine a student's level of learning. This was a departure from the normal forms of assessment in the courses within the UniSA's aviation programme.

In previous years, the final assessment of student learning in the advanced navigation and flight planning courses had been mediated by way of examination. This allowed an assessment of critically important aspects of aviation education: speed and accuracy. It also allowed an assessment of an individual's competence free from the risk of plagiarism. However, with the vast amount of knowledge that a student must learn and then be able to apply, one has to consider whether a three-hour examination can adequately assess all, or realistically even an adequate proportion, of a student's learning in the navigation and flight planning courses.

To this end, the project investigated a compromise assessment: the one-day assignment, which included beneficial elements from both an examination and an assignment. This was hypothesised to both adequately assess a student's level of learning in the courses and his/her ability to apply it to a real life situation or scenario. It also enabled some assessment of speed and accuracy as there was some realistic time limit

Weather

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FORECAST ROUTE SECTOR WINDS AND TEMPERATURES - PAGE 1
             BUREAU of METEOROLOGY - BRISBANE     07:13 UTC, 04/11/2006
---------------------------------------------------------------------
           ISSUE 040420               VALID 040300 - 040900
---------------------------------------------------------------------
FL -ISA YHML/YSSY YSSY/YBBN YHML/YPAD YHML/YHHB YPAD/YPOD/YHHB

445 -56 2905559   2504063   3005556   3004555   3005055 3004554
385 -56 2905056   2703056   2906553   3005552   2905552 3005051
340 -52 2905551   2802547   3007551   3107052   3006550 3106551
300 -45 3005041   2602536   3007044   3107045   3006545 3107046
235 -32 3004024   2402021   3005529   3005529   3005030 3005530
185 -21 3003013   3201011   3004017   3004517   3004018 3004519

FL -ISA YHML/YHDG/YBBN  YHML/YGTH/YWLG  YSSY/YHCO/YHHB  YSSY/YGTH/YPAD

445 -56 2905560 2504563 2905558 2705562 2905060 3004556 2805561 2906058
385 -56 2805556 2503555 2906555 2706555 3105057 3106053 2805056 2907054
340 -52 2806051 2702546 2907552 2705549 3105050 3106552 2805050 2907551
300 -45 2905041 2602536 3006042 2703539 3004539 3006544 2904039 3006542
235 -32 3004024 2402021 3105025 2802521 2903524 3005527 2903023 3105026
185 -21 3002512 3100511 3003514 3001510 3002512 2905016 3102011 3103514

FL -ISA YBBN/YBHK/YBCS  YWLG/27S148E/YBPNYSSY/28S149E28S149E/YEML/YBTL

445 -56 2304564 2302566 2505564 2404565 2605063  2405065 2404065
385 -56 2304552 2303551 2506053 2305052 2604555  2405553 2304551
340 -52 2403043 2203039 2304545 2204041 2603047  2204043 2204040
300 -45 2502535 2302032 2302536 2203033 2702537  2202534 2103032
235 -32 2302019 2602017 2301520 2302018 2501521  2202019 2402018
185 -21 1700508 2101005 2500509 1801008 2801010  1800509 2001006

FL -ISA YBBN/25S148E/YBHAYBHA/YPDN YSSY/YTAH/YBHK  YBCS/YBHA YBCS/YHID

445 -56 2304564 2604566 2801567   2504564 2304565 2502567   2401567
385 -56 2305053 2405052 2402052   2504055 2305052 2303052   2501552
340 -52 2403044 2304542 2202041   2602546 2303541 2203040   2501540
300 -45 2402535 2203533 2102031   2602536 2402534 2102531   2501530
235 -32 2202019 2102017 1701015   2402021 2402018 1901515   2600515
185 -21 1500009 1601006 1201503   2900510 1701007 1601004   1500503

FL -ISA YBBN/YSDU YSDU/VENEL/YPAD YSSY/APOHA APOHA/27S138E/YBAS

445 -56 2504563   2806061 2906058 2706062    2708563 2707565
385 -56 2504055   2707055 2907554 2706556    2709053 2708052
340 -52 2603046   2806049 2908050 2705049    2707047 2708043
300 -45 2602536   2804539 3007042 2803538    2805537 2706534
235 -32 2402021   2903522 3005026 2802522    2903521 2804019
185 -21 3000510   3102011 3103515 3101510    3002508 2902507

FL -ISA YHML/VENEL/YLEC YLEC/YBASYBAS/19S133E/YPDNYBBN/YWLG

445 -56 2906058 2807560 2808063  2704567 2801568 2404564
385 -56 2907055 2808555 2809553  2705053 2402052 2404554
340 -52 2907552 2908049 2808545  2605042 2302040 2503046
300 -45 3006542 2907039 2807036  2604532 2101030 2502536
235 -32 3105026 3005023 2904521  2602517 1301015 2302020
185 -21 3003514 3003511 2903008  2901005 1101504 2900510
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Figure 1: Route sector winds and temperatures.

imposed on the solution of the problem. The assignment tested a student's knowledge using a scenario-based approach to a full-scale highly realistic flight planning situation.

EXPERIMENTAL DESIGN

The students were given a typical flight planning scenario as shown in Figure 6.

The students were directed to refer to navigation chart ERC H2 (Figure 5) and plan a flight from Brisbane (YBBN) to Adelaide (YPAD) on 4 November at 0600 UTC. They were asked to consider all the weather information (Figures 1, 2 and 3) and carry 50 adult, 40 adolescent and 20 child passengers with their associated baggage and carry-on luggage. They were given some guidance to the seating of the passengers to ease the task of marking the assignment. They were directed to consider the abnormal operations involving a depressurised situation and an engine failure situation. This is the normal flight planning requirement. Given all these variables, they were asked to load the aircraft and plan the flight by the most appropriate flight route and altitudes. This presented the students with a very realistic flight planning and loading scenario.

In order to assess whether the examination technique of assessment or the scenario-based

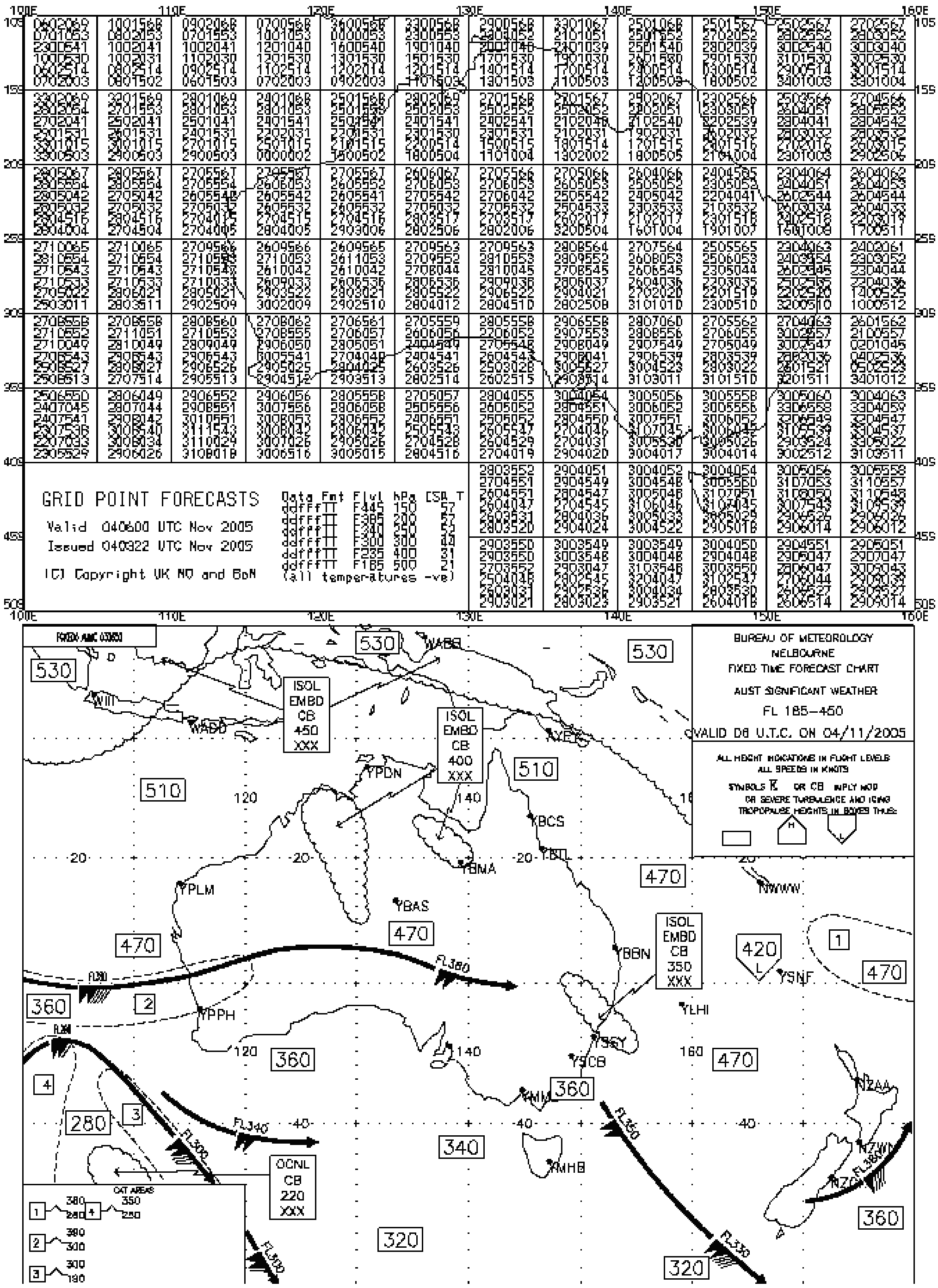

Figure 2: Grid point forecast and significant weather chart.

one-day assignment technique of assessment improved the assessment of student learning, the following methodology was applied. It was assumed, given the anecdotal evidence, that the use of scenario-based teaching improved student learning. This project investigated whether this learning was being assessed to the full extent. Therefore, it was concluded that if student results were improved by using the scenario-based assessment, then the full extent of learning in all areas was being accurately assessed.

Therefore, two hypotheses were formulated:

H_0: Using the scenario-based assessment had no effect on student results in *Navigation and Flight Planning 2*.

H_1: Using the scenario-based assessment had an effect on student results in *Navigation and Flight Planning 2*.

Two sample sets were extracted from the student results database for *Navigation and Flight Planning 2*. Sample 1 consisted of 61 students who had completed the course *Navigation and Flight Planning 2* in the three years immediately prior to the introduction of

```
*ADELAIDE YPAD
    04:22 UTC, 04/11/2006
    TAF YPAD 040422Z 0606 23010KT CAVOK
    FM08 16007KT CAVOK
    FM16 04010KT CAVOK
    FM02 33012KT CAVOK
    T 22 19 15 14 Q 1018 1017 1017 1017

    05:33 UTC, 04/11/2006
    TTF METAR YPAD 040530Z 23005KT CAVOK 22/08 Q1018
        RMK RF00.0/000.0
        NOSIG

*MELBOURNE YMML
    04:27 UTC, 04/11/2006
    TAF YMML 040427Z 0606
    19010KT 9999 SCT045
    FM11 12006KT CAVOK
    FM03 19012KT CAVOK
    T 18 16 14 13 Q 1019 1021 1022 1022

    05:32 UTC, 04/11/2006
    TTF METAR YMML 040530Z 17012KT 9999 FEW045 BKN230 16/07 Q1021
        RMK RF00.0/000.0
        NOSIG

*SYDNEY YSSY
    04:44 UTC, 04/11/2006
    TAF YSSY 040444Z 0606 16015KT 9999 -SHRA FEW015 SCT030 SCT120
    FM09 15010KT 9999 -SHRA SCT015 BKN025
    FM03 13012KT 9999 FEW020 SCT030
    INTER 0624 5000 SHRA BKN015
    T 20 20 19 19 Q 1019 1021 1022 1022

    05:34 UTC, 04/11/2006
    TTF METAR YSSY 040530Z 18009KT 9999 SCT016 BKN025 20/18 Q1020
        RMK RF00.0/000.0 HZ
        INTER 0830/1130 5000 -SHRA BKN015

*BRISBANE YBBN
    04:11 UTC, 04/11/2006
    TAF YBBN 040411Z 0606 05013KT 9999 SCT025 SCT040
    FM11 08008KT 9999 -SHRA FEW010 SCT025 BKN040
    FM00 04015KT 9999 SCT025
    INTER 1224 3000 SHRA BKN012
    T 25 24 24 23 Q 1018 1020 1021 1020

    05:31 UTC, 04/11/2006
    TTF METAR YBBN 040530Z 05008KT 9999 FEW020 BKN250 23/20 Q1020
        RMK RF00.0/005.2
        NOSIG
```

Figure 3: Aerodrome forecasts.

the scenario-based assessment when the examination was used for assessment. Sample 2 consisted of 65 students who had completed the same course in the three years immediately after the introduction of the scenario-based assessment.

The student data was de-identified and an Analysis of Variance performed to determine, within statistical significance, whether or not the two samples were sufficiently different to have originated from two different populations.

RESULTS

An analysis of variance (F test) was performed between Samples 1 and 2. Sample 1 had a sample size of 61 students and a mean mark of 57.4%, while Sample 2 had a sample size of 65 students and a mean mark of 66.1%. The degrees of freedom between the samples was 1 and within the samples 124. This gave a critical F_{crit} value of 3.92 and 6.85 for a significance level, α, of 0.05 and 0.01, respectively.

The calculated F value, F_{obt}, was 5.72. This value was greater than F_{crit} of 3.92 (α=0.05) and therefore we can conclude that the two samples did not originate from the same population with a significance greater than α=0.05. In other words, there is a probability greater than 95% that the two samples were independent and did not originate from the same population (Table 2).

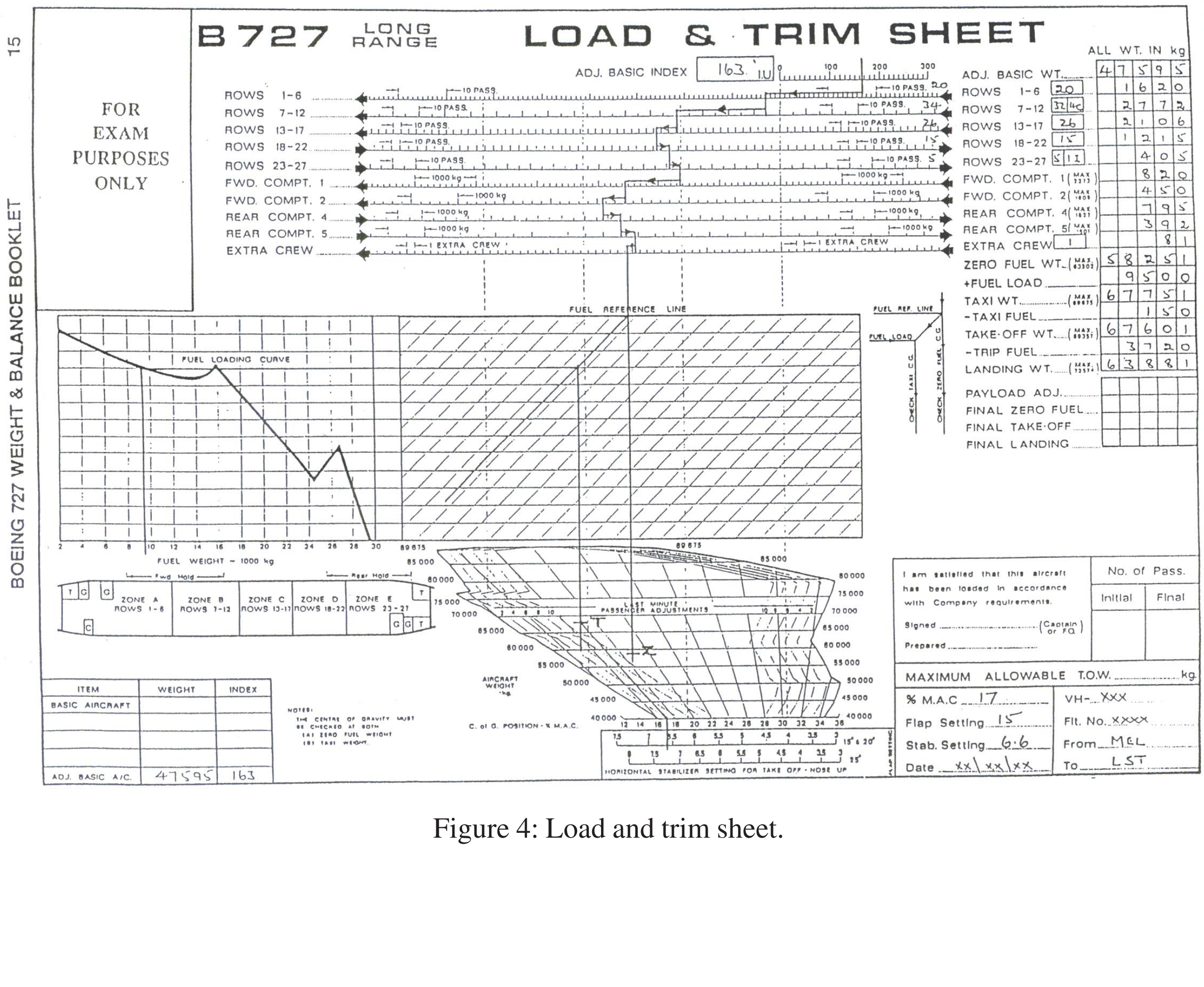

Figure 4: Load and trim sheet.

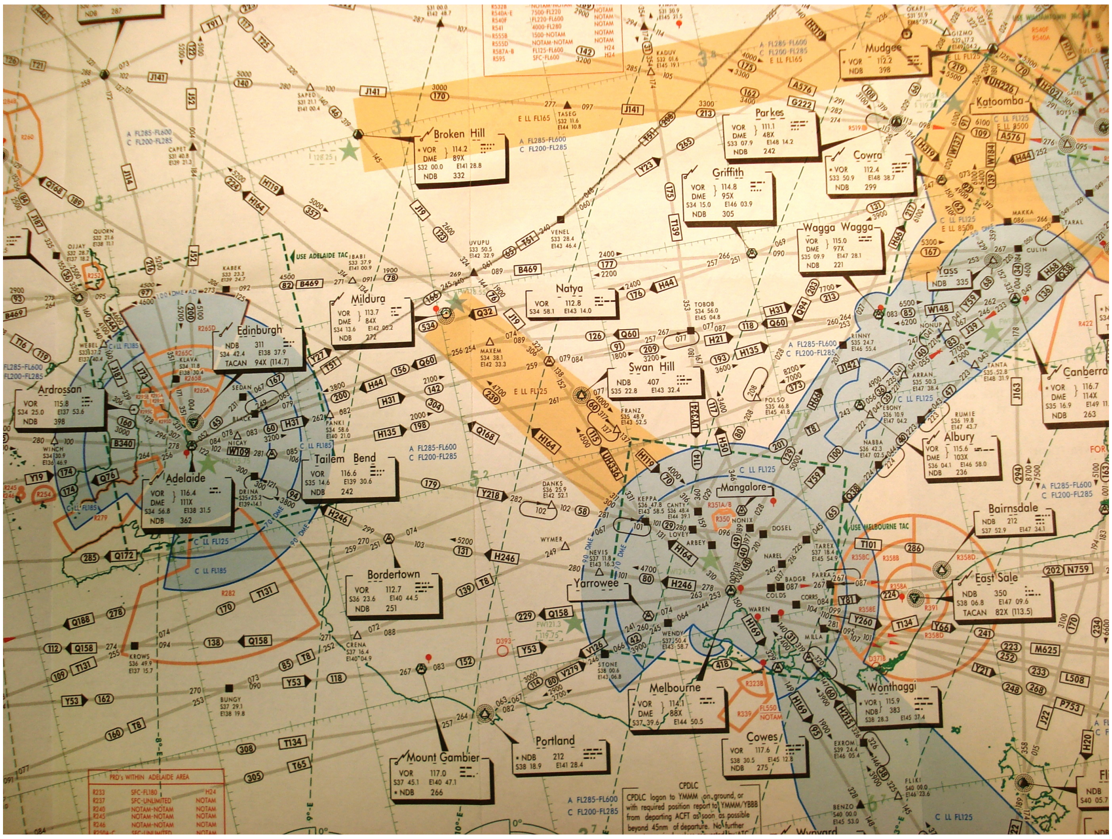

Figure 5: En route navigation chart.

Thus, the null hypothesis, H_0, is rejected and the conclusion is that the alternative hypothesis, H_1, is more likely. Therefore, the use of a scenario-based assessment technique in *Navigation and Flight Planning 2* did have an effect on student performance as judged by their final results (to a significance of α=0.05). Further, it can be stated that, given the differences in the mean marks between the two samples, student results improved.

No other contributing factors that could have acted as independent variables were investigated. As the samples included student results across a six-year time span, there could have been more than one independent variable, such as variations to the delivery method and the delivery of complementary courses from year to year, which may have had an effect on the dependent variable, the students' final mark for the course

CONCLUSION

Given the results of the analysis of variance (F test) analysis between the two sample sets extracted from the student results database over a six-year period, it would appear that the two samples did not come from the same population of student results to a significance of α=0.05. Therefore, it was concluded that the use of a one-day assignment that was scenario-based did assess the students' learning to a deeper level.

It is clear from the means of the two samples that students scored higher marks in the scenario-based assignment than in the examination. This was most likely because it allowed a thorough assessment of the whole course rather than a smaller part of the course. This allowed lesser able students to achieve recognition for the elements of the course that they knew well. These elements may not have been assessed in the examination. Also, it could be that students performed better because they were able to apply themselves better to a real world holistic problem or flight planning scenario than in an artificial situation with a number of small unrelated problems as occurred in the examination format.

Student feedback indicated that the students preferred the one-day assignment to the traditional three-hour examination, even though the one-day

Table 2: Results of the Analysis of Variance.

	n	Mean	Fobt	Fcrit $\alpha = 0.05$	Fcrit $\alpha = 0.01$
Sample 1	61	57.39	5.72	3.92	6.85
Sample 2	65	66.08			

This flight refers to **ERC H2**

Aerodrome Information & Flight Details

Use highest FL's available for normal operations and 1 engine inoperative operations. Use FL130 for DP Operations.
Normal Ops. Cruise at Mach M0.80.
BEW 47,250 kg. BIU 165.

YBBN, YPAD, YMML, and YSSY are available for use.

Use only these aerodromes

Questions

1. Plan a flight from YBBN to YPAD on 4 November ETD 040600.

Plan to carry minimum fuel and maximum payload. If an alternate aerodrome is required flight plan via appropriate route and flight level. Use the TTF/METAR for the ambient conditions at YBBN

You are required to carry 50 Adult, 40 Adolescents & 20 Children (including 20kg of checked baggage for each passenger) and as many 150kg containers as possible on the flight? (Assume 15 Adults and 5 Adolescents sit in Rows 1-6 and where possible 1 Child sits between 2 Adults in the other rows.)

All working must be shown and easy to read. **A Normal Ops flightplan, the most critical abnormal Ops flight plan and a load and trim sheet must be submitted with your working.**

(Note: If you cannot correctly argue whether DP OPS or 2E OPS is more critical you must do both!)

Please highlight your answers to the following on the last page of your exam book.

MBRW= ____________ Min FOB @ BR= ____________
Maximum P/L= ____________ %MAC ____________

Stab setting ____________

Figure 6: Typical scenario-based assignment.

assignment assessed a considerably larger body of knowledge and required the students to undertake a significantly larger amount of work.

There was some concern that the improvement in the students' results may be dependant on variables other than whether the students undertook the scenario-based assessment. However, none of these was investigated. The technique of using scenario-based one-day assignments for assessment is being considered for implementation in other aviation courses that, because of their operational nature, would probably lend themselves naturally to this approach.

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BIOGRAPHY

Steve Thatcher was a founding member of the team that introduced Australasia's first tertiary award course in aviation in 1985 at the University of South Australia's (UniSA) antecedent institution, the South Australian Institute of Technology. This established the aviation discipline in the Australasian region. He remains the longest serving aviation academic in Australia.

Mr Thatcher was also a founding member of the team that established the University's Aviation Academy in 1990, which became the first university in Australasia to own and operate a flight training school.

In 1993, he founded the Aviation Education, Research and Operations Laboratory (AERO Lab) to conduct research into aviation psychology, aviation human factor, aviation safety and aviation education. He is currently the Team Leader of AERO Lab.

He was a founding member of the Australasian University Aviation Association and served as its Secretary for a number of years.

In 2005, he successfully negotiated the SA Government Fixed Wing Shark Patrol Service for UniSA Aviation. The UniSA Shark Patrol provides a valuable community service and has provided graduate pilots with valuable flight time experience at a stage in their careers when it is relatively difficult to get flight experience. He recently won the Chancellor's Award for Community Engagement for the UniSA Shark Patrol.

He has qualifications in physics, psychology, education and aviation. He has been a Jackaroo in South West Queensland, a graduate engineer for British Aerospace (UK) and has lectured in physics, electronics and aviation. He holds a Commercial Pilot Licence and a Grade One Instructor Rating. He is also on the editorial and review boards of several journals and conferences.

He was recently awarded the UICEE's Silver Badge of Honour for *...distinguished contributions to engineering education, outstanding achievements in the globalisation of engineering education through the activities of the Centre, and, in particular, for remarkable service to the UICEE.*

10th Baltic Region Seminar on Engineering Education: Seminar Proceedings

edited by Zenon J. Pudlowski

The successful *10th Baltic Region Seminar on Engineering Education* was conducted at the University of Szczecin, Szczecin, Poland, between 4 and 6 September 2006. The Seminar attracted participants from 18 countries worldwide. Just under 40 papers have been published in this Volume of Proceedings, which include an informative Opening Address about the UICEE European Headquarters and its involvement with European engineering education, plus various Lead Papers. All of these published papers present a diverse scope of important issues that currently affect on engineering and technology education at the national, regional and international levels.

The paramount objective of this Seminar was to bring together educators from the Baltic region to continue dialogue about common problems in engineering and technology education under the umbrella of the UICEE. To consider and debate the impact of globalisation on engineering and technology education within the context of the recent economic changes in the Baltic region, as well as the increasing importance placed on fostering students' entrepreneurship skills, were also important objectives of this Seminar. Moreover, the other important objectives were to discuss the need for innovation in engineering and technology education, and to establish new links and foster existing contacts, collaboration and friendships already generated in the region through the leadership of the UICEE.

The papers incorporated in these Proceedings reflect on the international debate regarding the processes and structure of current engineering education. They are grouped under the following broad topics:

- Opening address
- New trends and approaches to engineering education
- Specific engineering education programmes
- Simulation, multimedia and the Internet in engineering education
- Education and training for engineering entrepreneurship
- Innovation and alternatives in engineering education
- New developments and technologies in engineering education
- Quality issues and improvements in engineering education

It should be noted that all of the papers published in this volume were subject to an international formal peer review process, as is the case with all UICEE publications. As such, it is hoped that these Proceedings will contribute to the international debate in engineering education and will become a source of information and reference on research and development in engineering education.

To purchase a copy of the Seminar Proceedings, a cheque for $A70 (+ $A10 for postage within Australia, and $A20 for overseas postage) should be made payable to Monash University - UICEE, and sent to: Administrative Officer, UICEE, Faculty of Engineering, Monash University, Clayton, Victoria 3800, Australia. Please note that sales within Australia incur 10% GST.

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Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

The New Alliance between Engineering and Humanities Educators*

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There is a growing awareness that professional engineers need a substantial acquaintance with a variety of subjects traditionally taught within the humanities. This awareness suggests a need for curriculum reform to offer adequate exposure to the humanities. In this discussion, it is argued that curriculum reform will not properly address the problem. This is for reasons both practical and philosophical. Practically, it is evident that the engineering curriculum is already quite demanding and is in need of expansion in multiple areas beyond the humanities. Philosophically, it is argued that the addition of more humanities courses to the engineering curriculum will not provide the kind of broadened understanding sought. The solution proposed is the creation of formal intellectual alliances between humanists and engineers to foster the reflective discourse needed to impute humanistic concerns into the problem-solving strategies of engineers. It is acknowledged that this approach places a greater demand on scholars in the humanities, but that this is an educational and social imperative.

INTRODUCTION

The argument is often made that engineers need more exposure to the humanities. This position reflects the claim put forth on many fronts that modern, scientific technology poses many questions of a highly value-laden nature that can only be addressed using the methods and insights of the humanities. Engineering educators generally agree with this proposition but ask how additional instruction in the humanities can be introduced to the undergraduate degree programme without weakening the already overloaded engineering curriculum. There is also the question of what instruction in the humanities is appropriate?

The list of authors regarded as essential in Europe and the USA is unlikely to be accepted in other parts of the world. The inclusion of the humanities in the globalisation of engineering education risks the reintroduction of a colonial or imperial mentality unless multicultural norms can be found. A recent study has argued that the history of the World Bank, whose mission was post-war reconstruction and development, shows that infrastructure projects cannot easily be divorced from cultural norms and values [1]. Thus engineering education faces incipient crises on two fronts: the pressure created by rapidly changing technology to include additional topics in the baccalaureate programme *and* the growing requirement for engineers to be able to make responsible cultural, political and social decisions that shape the future of the world.

A simple curricular solution cannot address adequately these profound challenges. Rather, engineering and humanities educators need to form discursive alliances, based on mutual respect, that will enrich understanding and create the basis for meaningful deliberation. The problem is not merely a problem for engineering education, but is a major philosophical, cultural, social, economic and political dilemma in our time. Surely, curriculum change regarding the relation between engineering programmes and the humanities is called for, but it needs to occur within an environment that nurtures fundamental discourse between

*A revised and expanded version of a lead paper presented at the *10th Baltic Region Seminar on Engineering Education*, held in Szczecin, Poland, from 4-6 September 2006. This paper was awarded the UICEE Best Paper Gold (joint Third Grade with two other papers) Award by popular vote of Seminar participants for the most significant contribution to the field of engineering education.

engineers, technologists, scientists and the full range of humanists and social commentators.

ENGINEERING EDUCATION

This discussion begins with a radical proposition. To wit: the efforts to reform engineering education, including those that recommend the addition to, or modification of, the curriculum to include project-based learning, teambuilding and leadership development, global competences, the improvement of communication skills and, perhaps most obviously, the enrichment of the humanities component, are all mistaken. This is not to say that they are not in the right spirit or that they are not authentic attempts to address crucial shortcomings. The problem is simply that they cannot be achieved in a way that will solve the problems that beset engineering education. This claim, however, goes beyond the usual pragmatic considerations associated with curriculum reform. The additional circumstance in this case is that it is difficult on purely conceptual level to state what humanistic knowledge is needed or desirable for engineers or technologists in our time.

Currently, engineering education exhibits two maladies. The first is within the narrowly defined domain of technical or engineering training, and has to do with engineering skills *per se* and with their relationship to science and mathematics. In a sense, this is because engineering itself has become both more technical and less technical. There are many illustrations of this seemingly contradictory phenomenon. More and more engineering projects are extremely scientific and require deep knowledge of a variety of disciplines covering the full spectrum from biology to physics. The representation of the knowledge from these disciplines tends to be highly mathematical as mathematics is the language that permits discourse between biology and physics. But at the same time, much of this is apparently simplified and made available with an impressive degree of operational sophistication, even to those with a minimal grasp of the underlying processes, by means of computer technology. Thus, many very complex processes are masked by pleasing and rather simple computer interfaces. This creates an illusion of competence and one of the unpleasant tasks of engineering education is often to dissuade students of false presumptions of understanding.

This problem is *epistemological*, and strikes at the very heart of what engineering and technology as disciplines are. Neither is science, although science, ie precise and demonstrated knowledge, is increasingly central to engineering and technological practice. Engineering is based upon the utility of specific knowledge although engineering discovery may occur in the absence of such knowledge. Technology is also related to science in the sense that it can often unlock the utility of science. Recent technology has done that with much of biological science, for example. Such unlocking adds a new human dimension to the science and changes what it is in itself. Thus, engineering/technology both uses and creates science. Indeed, it is through engineering that science becomes human science.

Engineers, for the reasons suggested above, perhaps more than ever before, need to be scientists and competent applied mathematicians. This is to say that engineering rests upon complex theoretical grounds, and that innovative engineering research and practice needs to cultivate and care for such grounds. The problem for engineering education is that the demands of rigorous and contemporary science education are simply more than can be fit into an undergraduate engineering programme. Moreover, the mindsets of science and engineering students are frequently inimical, if not, then they share only limited commonalities. Engineering students often express impatience with, and distaste for, their required science courses. This leads to the other side of the dilemma. If engineering students prefer practical, *hands-on* project-oriented, experiential learning while disdaining theory, the fact is that the majority enter engineering school with very little background for this kind of work. It is also increasingly rare to meet students who have had much or any experience tinkering or repairing equipment. Those students who have rebuilt a carburettor or put together a *ham* radio station are few and far between. In part, this is due to technological advancement and the ubiquitous presence of the microchip that makes it incredibly difficult or impossible to figure out how something works by carefully disassembling it and looking. The discovery of mechanical principles that could be achieved simply by taking an alarm clock apart is no longer an option found on every bedside table.

These are dilemmas for engineering education. Students need more science and advanced mathematics in order to prepare for the sophisticated, advanced and innovative engineering work that will shape the future. The rigour and intensity of this kind of study is such that it cannot simply be added to the curriculum. Furthermore, it is not what most engineering students are well prepared to do or desire. On the other hand, what they do desire and what is also essential to engineering, ie *hands-on* experiential project-based learning, is something that most students have almost no background for. So the challenge engineering faculties face, before being asked to improve their students' communications skills, leadership tendencies and project management acumen, is already nearly overwhelming. Where, short of making the undergraduate degree a five or six-year programme, is humanities education supposed to fit in? It is partially for these reasons that there are now calls to make the MS or MEng degree the first professional degree for engineers.

The realistic answer is that it cannot. From the standpoint of the humanities, it is important to acknowledge this and imagine an honest strategy to address the loss. The adjective *honest* is used mindfully. For the temptation will be, in order to save faculty lines and assuage accrediting agencies, to offer professional courses of instrumental value – perhaps something like technical writing – and claim that such instruction, without doubt valuable, provides all the humanities that engineers really need. If this kind of cosy relationship were to become normative, it would be a dishonest representation of the humanities, and do a great disservice to both the engineering profession and the public at large, evermore in need of engineers whose human perspective is both long and broad.

Thus, the thesis contained in the radical proposition put forth at the outset: the humanities must become a partner, equally powerful and equally determinative, with engineering (and not an ever-diminishing under labourer) mutually engaged in the project of educating the engineer of the future.

A CRISIS IN OUR TIMES

The stage has been reached where universities around the world now aspire to be true to their name and, in the argot of the day, be *comprehensive.* Engineering, once a stepchild banished to the periphery, to sit *next to the stove* so to speak in the *house* of intellect, is now being introduced in the *front parlour* as proof of a university's commitment to the future. Princeton University now showcases its engineering school while New York University laments its decision a quarter of a century ago to abandon its own (although it is currently discussing the possible re-merger with their abandoned engineering school). From the point of view of research or public service or economic growth through government funding and collaboration with industry, there is a powerful motivation for universities to emphasise engineering. These motivations, however, guarantee neither excellence nor contemporaneity for engineering education. Indeed, these motivations, if left to their own purposes, are likely to erode the quality of education.

Some may feel that the idea engineering *education* is something of an oxymoron. Engineers, the argument goes, should be well trained in engineering, science and mathematics as appropriate. Such competent engineers should further be prepared to work closely with representatives from other specialisations in pursuit of wealth and the common good. One could make similar arguments on behalf of legal or medical education as well. In all cases, such arguments are dangerous as they foster the situation where the professionals most instrumental in guarding the well being of individuals and the commonweal are not by virtue of their professions informed about the texture of human value and the history of human tradition. Yet the situation is most emphatic in the case of engineering. Engineers have traditionally been subservient, taking orders as in the military. But in the present, where modern, scientific technology has empowered engineering to make irreversible changes to the natural order, changes that may most profoundly alter the character and quality of life, engineers must at least share in the choice-making processes where their expertise is unknown by anyone else.

Additionally, there is what may be called the paradox of technology. The paradox is that technology seems both to expand and limit human freedom. How is this possible? Technology, whether through mechanical or other means, can alleviate much human labour without loss and generally with a gain in productivity. Thus, technology can produce both leisure and wealth. The consequent increase in both liberates humanity from much of the slave-like effort needed to survive. In this sense, we are freer because we are less obligated to the onerous requirements of self-preservation. However, at the same time, technology turns into a new master as we become more dependent on it, eventually lacking the skills, knowledge and disposition to manage our own lives autonomously. Engineering, as the concrete practice of technology, in fact positions us along this human freedom continuum between empowerment and dependency. The determination of whether this positioning is done with understanding, wisdom and discernment is part of the subject matter of the humanities.

In short, for these reasons, engineers must be humanists in order to exercise their vocation responsibly. But the trends in education, for powerful technical and economic reasons, seem to obviate this necessity. What is the solution?

AFFILIATION, CONFEDERATION, PARTNERSHIP?

Neither addition nor assimilation is possible. The relationship between engineering and the humanities is one that traditionally has not been close, and for the reasons pointed out, the engineering curriculum cannot add new humanities courses to its already-crowded programme. Nor is it reasonable to propose that engineering courses can take on the additional requirement of teaching humanities (this is a different issue than whether or not the expectations for clear and precise communications can be increased in engineering courses). Also, given the growing technical complexity of engineering, it is not advisable to assimilate engineering into the liberal arts curriculum as another major, along side of physics, for example.

The solution may be based upon a carefully-considered partnership between the humanities and engineering. In this partnership, engineers and humanists each retain their own intellectual identity, their own perspectives and values, pedagogical methods and, of course, their own status and degree of autonomy within the university. Humanists should not emulate engineering teachers nor vice versa. However, these distinctions and boundaries should not imply alienation from each other. While intellectual identity and pedagogical methods are distinct, there remains a field of common ground large enough to permit mutually beneficial rules of engagement.

How can a meaningful, from the multiple standpoints of education, research and public service, discourse between humanities and engineering be created? Is there really a two-culture problem that must be overcome before such discourse is possible or likely? Can engineers and humanists collaborate on crucial world issues that are both technical and value-laden, such as global warming? Is any of this plausible in the context of education?

In order to address this, consider the example of an experimental course, supported by the NSF Gateway coalition of engineering schools, offered jointly by the Polytechnic University and the Cooper Union for the Advancement of Science and Art [2]. The Polytechnic University is the second-oldest private engineering college in the USA, while Cooper Union, established in 1859, is ranked among the nation's oldest and most distinguished institutions of higher learning. Despite the fact that both are urban institutions located in New York City, are of comparable size, and are both old private universities serving similar populations, there are nonetheless, as suggested by their names, deep and profound differences between them. The Polytechnic University, for many years known as Brooklyn Polytechnic Institute or *Brooklyn Poly*, carries the image of a gritty, roll-up-your-sleeves, no-nonsense place training practical and technically competent individuals ready for the industrial workplace. The Cooper Union, on the other hand, is comprised of the School of Architecture, School of Art, a Faculty of Humanities and Social Sciences, as well as the Engineering College, and conveys an image more often associated with men and women of letters than with those involved with industry.

The experimental course enrolled half of its students from the faculty of humanities and social sciences at Cooper and half from the engineering disciplines at Polytechnic. The course similarly was team-taught by faculty from the humanities and engineering. The course was offered on two occasions: the first time under the general heading of *Cities* and the second *Bridges*. In these courses, the engineering faculty dealt with the obvious technical issues while the humanities faculty ranged over a broad spectrum of aesthetic, cultural, historical and value questions. The students worked in teams and the major component of the course was a design project.

The subject matter in both cases (*cities* and *bridges*) was easily integrated across disciplines. Remarkably, the engineering faculty expressed such observations as that their presentations of the structural aspects of bridge design were enhanced and motivated by the students' awareness of aesthetic and cultural issues. The engineering problems, in other words, were placed in a real-world context that students related to. There was no, as might have been feared, adulteration or diminution of the technical content presented to the engineers; engineering and non-engineering students had some alternative assignments to correspond to the differing skill sets they brought to the course.

What was striking about the course had less to do with the ease by which the content could be integrated, but rather with the responses of the students to this type of learning environment. Indeed, it is from these responses that one can learn about the ideal relationship between engineering and the humanities.

At the outset, it was clear that the students from the two groups (humanities students and engineering students) exhibited very different learning styles. For both the engineering and humanities students, these differences made them reluctant to interact with students from the other group. The instructors (who also exhibited distinct and different learning and teaching styles) had anticipated this and, therefore, assigned students to teams that were diverse. Although the dramatically different approaches to learning never changed, this turned out to be an advantage. The difference became the basis for a rich discourse among the student team members that explored the issues inherent in the assigned project from a multiplicity of perspectives and interests greater than would have been likely in more monolithic teams. In short, humanists and engineers had come together to collaborate on what was essentially an engineering exercise and did so, to their mutual benefit, without each group abandoning their native approach.

To say that the project *was essentially an engineering exercise* of course makes a strong statement about the nature of engineering as a branch of the humanities. Public projects, such as bridges, clearly exemplify the need on the part of engineering for powerful interaction and communication with a wide variety of non-technical points of view. This kind of interaction suggests the model within the academy for the relationship between engineering and the humanities.

In the context of this experimental course, the engineering students learned not particularly academic humanities, but genuine humanities nonetheless. Likewise, the humanists became educated in engineering, although clearly not to the level of a student aspiring to become a practising engineer. Such courses may exemplify the best model for the teaching of humanities to engineers and, by extension, suggest the most appropriate model for the best relationship between engineering and humanities faculties. It is only when the relationship between the two faculties is healthy and stable that we can hope for collaborative education.

This point is vital. What is called for is not so much a revision or expansion of what constitute engineering, but rather a profound reorientation of what is called the humanities. A legitimate specialisation within humanistic studies is technology. Humanist scholars who focus on technology have an intellectual responsibility to understand it, so to speak, from the inside and not only from the perspective of those who live (as we all do) in the technologically constituted *lifeworld*. An insider's understanding of technology is what engineers have. The imperative is for humanist scholars to learn how to view the *lifeworld* from the perspective of engineering. Only then can a meaningful dialogue be obtained between technologists/engineers and humanists.

A recent conference was devoted to a consideration of the new role for the humanities in Asia [3]. The specific emphasis was *the fine line* between the humanities and sciences. A number of very interesting issues emerged. The first had to do with the fissures existing within the community of humanists. These fault lines generally followed the contours established by the world's universal systems, be they religious or secular. Is there any true way to reconcile the proclamations of, say, Christianity and Confucianism? A second set of debates focused on the validity of the variety of methods used by the human sciences (a term still understood in Europe). One easily gained the sense that intellectual collaboration was likely to be easier between any of the humanities and the natural sciences than it is within the family of humanists. A presentation advocating the collaboration of humanists and engineers was well received, although perhaps only because of its surprising novelty. In fact, very few academic humanists have ever seriously considered collaboration or shared discourse with engineers. The opposite is also no doubt the case. However, as evidenced from this conference, there is, at least from the humanistic side, an openness towards this approach and a reservoir of good will deep enough to sustain it into the future. How might cooperation between academic humanists and engineering educators be promoted? Since curricular *reform* has been ruled out, at least in the near term, the options left are all forms of institutional collaboration. Yet to encourage the free exploration of ideas and to minimise the possibly detrimental effects of bureaucratic control, these collaborative institutions should not be the agencies of university administrations. What form of institutional collaboration is desirable?

A CENTRE FOR LIBERAL ARTS IN ENGINEERING EDUCATION

The Polytechnic University hosts the newly-established *Centre for the Liberal Arts in Engineering Education*, a satellite centre of the UNESCO International Centre for Engineering Education (UICEE). The mission of this satellite centre includes the creation of a network that will proliferate discussion between academic humanists and engineering educators, together with representatives of industry, government and non-government organisations. The Centre will join the international Consortium of Humanities Centers and Institutes (CHCI), thus opening channels of communication between engineering educators and humanists globally that have not existed previously [4]. It is also likely that this UICEE satellite centre will be represented in an industry-university research centre.

It may be the case that engineers have a more acute appreciation for the importance of the humanities than humanists do for engineering. In fact, academic humanists tend to locate engineering education beyond the horizon of their interest or concern. For this reason, it is necessary for engineering educators to take the initiative and reach out to develop formal *intellectually-based* institutional relationships.

Engineers have not traditionally been seen as residents of the house of intellect. Wittgenstein began as an aeronautical engineer and Spinoza was a lens grinder, but their fame derived from investigations far afield from such training. If engineering educators are going to reach out to their colleagues in the humanities, what will be the reason for their overture? When C.P. Snow discussed *the two cultures*, he noted a certain condescension on the part of university humanists directed, for example, towards the possibly naïve readings of literary texts undertaken by members of the scientific community [5]. One recognises a form of this attitude persisting today as when, in a typical instance, a physicist expresses his faith and offers an interpretation of the Christian Bible from the point of view of a scientist only to be told by literary deconstructionists that the reading is hopelessly uninformed.

As noted in the example of the experimental course discussed above, a successful exchange does not happen when participants leave the domain of their own expertise. When discussing bridges, the engineering and liberal arts students discovered that they had, each from their own perspectives, interesting and valuable insights to offer their teammates from other disciplines. Therefore, when engineers address humanists, they should articulate their own expertise on issues of common human concern. In so doing, they should not use the jargon of engineering practice and in fact, unfortunately, they may need to simplify technical problems just in order gain a hearing. But since the great majority of engineering projects address fundamental human concerns on what engineers should do, indeed for the sake of the future, they must be understood as profound issues for the good of humanity itself. One can say – quite legitimately – that engineering is a humanistic discipline for the very reason that it is engineers who create, design, implement and operate (CDIO) the *human* world. What engineers do is what makes possible human freedom and liberty, allows us to survive in nature with sufficient leisure to pursue the life of the mind, and grants us the security needed to raise families and make choices based on preference.

The persistence of the *two cultures* within higher education especially is no longer tolerable. It is truly an imperative for humanist scholars to engage in substantive and discursive dialogue with the community of technologist/engineers.

When we reflect on the crucial issues facing the world, such as global warming, adequate housing, pandemic disease, energy, mass transportation, communication, information, education and so on, we realise that everyone requires engineering. And they require engineering not simply because they have major technological aspects, but also because they can only be approached effectively by that kind of practice that is ultimately identified with engineering. It is engineering practice that makes changes and sustains the world.

Of course, only engineering in the narrow sense does not provide the basis for good judgements and responsible solutions. Nor in the environment of geopolitics and global economics does engineering alone have sufficient means to implement its solutions. For engineering to do the work of engineering, it must be a collaborative partner with the other human sciences.

Since all the crucial issues facing humanity are global, the movement to establish meaningful discourse between engineers and humanists (and economists, lawyers and politicians) must likewise be international and global. The problems and challenges facing the world do not know political boundaries. It is on this level that engineering can make a great contribution. The skills of engineering cross borders easily and much of what engineers are the acknowledged stewards already has international standards. Good engineering practice has not been subordinated to political interests to the same degree as other disciplines (such as economics or law). Even natural science has been politicised to an extent greater than engineering. This is not to say that engineering is free from political influence, on the contrary, but there is a greater possibility for an apolitical engineering than is the case in many other endeavours. As a discipline and practice, engineering has a better opportunity to achieve worldwide acceptance than many others. As engineering makes its overtures to the humanities, it must do so with a global consciousness (thus helping repair some of the cracks noted in debates among humanists), mindful of the need to establish standards respectful of human interests and not simply responsive to economic opportunities.

The burden to form this alliance does not rest solely on the shoulders of engineers. Although it is true that the majority of humanists show little interest in engineering questions, there are important exceptions. However, some of the most prominent, for example the influential thinkers Martin Heidegger and Jaques Ellul, come to mind, who argued that technology was a pernicious and nearly totally determining influence on the quality of human existence [6]. According to them, there are highly problematic, undesirable and inevitable social, political and economic consequences of technology. They do see technology in the service of the good life, but anticipate a future where we are doomed to lives organised and priorities set by the demands of machines and systems.

Yet other influential humanists and philosophers have responded to this type of techno-pessimism with powerful analyses that appreciate both the potential danger *and* redemptive power of modern scientific technology. Two such thinkers whose work guides the research at the *Centre for Liberal Arts in Engineering Education* are Hans Jonas and Carl Mitcham. The latter has written an interesting book that relates engineering and philosophy: *Thinking through Technology: The Path between Engineering and Philosophy* [7]. Jonas, who was one of Heidegger's most famous students and who broke dramatically with him, has articulated the ethical challenges posed by technology in his very influential (in Germany and elsewhere in Europe) book, *The Imperative of Responsibility: In Search of an Ethics for the Technological Age* [8]. These two books can help shape the intellectual agenda for collaboration between engineering educators and academic humanists.

The *Centre for Liberal Arts in Engineering Education* will endeavour to establish a dialogue between engineering educators and academic humanists; it will affiliate with organisations in order to create networks and raise funds to create scholarships to support the PhD education of *engineer humanists*. As a sub-centre of the UICEE, organised and operated by faculty, the Centre is global in outlook and will work closely with all of the Partner institutions of the UICEE network. The Centre will also collaborate closely with the Polytechnic University Institute for Global Alliances for Technology Education (InGATE) to promote international student and faculty exchange in technology and engineering education and research. The Centre has plans to maintain a Web site and, in the future, publish the results of its sponsored research.

CONCLUSIONS

This discussion has been wide-ranging, but specific conclusions may be drawn, as follows:

- The required curriculum in engineering education is expanding beyond the point where programme revision can absorb all of the new demands;
- Especially given the increased technical and scientific components needed for quality engineering education, the expectation that the curriculum can accommodate new or even sustain the present proportion of humanities courses is unrealistic;
- Much of what is needed in engineering education can be provided through new modalities of instruction. Experimental courses, such as the *Bridges* course described above, put engineering and humanities *problemata* on the same level and foster cross-disciplinary approaches to solving them;
- This situation creates a crisis in education as a meaningful synthesis of an informed humanistic outlook and engineering training is essential to address the crucial issues of our times;
- Collaboration on a high order intellectual basis between engineering educators and academic humanists will help create a new discourse that will improve the quality of education on all levels;
- The conflict of value systems in a pluralistic world has led to an exacerbated polarisation and politicisation on issues of vital concern to humanity. Engineering may be able to help mediate among contending interest groups;
- Engineering practice has succeeded in the creation of internationally-accepted standards to an extent greater than in many other disciplines, putting engineering in an advantageous position for the global exchange of ideas;
- The *Centre for the Liberal Arts in Engineering Education* will, through research, dialogue and global alliances, address these crucial issues.

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BIOGRAPHY

Harold P. Sjursen is a professor of philosophy and the Associate Provost for International Education and Research at the Polytechnic University in Brooklyn, New York, USA. He is the Director of the *Centre for Liberal Arts in Engineering Education*, a satellite centre of the UICEE, and the Center for Philosophy and Technology Studies at the Polytechnic University. His publications range widely and include studies of European phenomenology and existentialism, the neo-Confucian thought of the Song dynasty, East-West comparative philosophy, the ethics of technology and globalisation. His current research centres on the ethical problems posed by technology in the global context. He was a student of Hannah Arendt and Hans Jonas at the New School for Social Research, where he earned his PhD.

In July, 2006, he was awarded the UICEE Silver Badge of Honour for …*distinguished contributions to engineering education, outstanding achievements in the globalisation of engineering education through the activities of the Centre, and, in particular, for remarkable service to the UICEE*. He is completing a book titled *From Tradition to Technology: the Ontological Ethics of Hans Jonas*. Prof. Sjursen is presently Chairman of the UICEE Academic Advisory Committee (AAC).

Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

The Transformation and Evolution of Undergraduate Environmental Engineering Education from Its Early Inception to the Present Status*

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Environmental engineering, from its early inception, has endured a lack of identity both as a profession and as a discipline in engineering. The field is broad and multidisciplinary in nature, and the foundation upon which it is built includes knowledge and understanding of concepts and ideas coming from the engineering and science fields. Environmental engineers are said to be a hybrid of an engineer and a scientist, thus making them the best profession to deal with environmental problems. Environmental engineering education has been undergoing substantial changes over the last few years in order to be more relevant and applicable in current times. In this article, the authors endeavour to trace the history and evolution of environmental engineering education in the context of changing societal needs and demands, discuss how it has developed into an engineering branch of its own merit and how this vital field was constructed in earlier times. The current status and future directions of environmental engineering are also elaborated on. In addition, some interesting statistics on the enrolment of students in various engineering courses and the attraction of women to environmental engineering courses are presented and discussed in this article.

INTRODUCTION

While environmental problems have rapidly accelerated within the last three decades, the response, in terms of environmental education for the engineering profession, is slow and has not accelerated at the same pace. Sadly, many existing engineering curricula have yet to integrate relevant environmental issues that pertain to the field of engineering. In particular, it was found that the issues have not been equally covered across all branches of engineering, especially in the field of electrical and mechanical engineering.

*A revised and expanded version of a paper presented at the *10th UICEE Annual Conference on Engineering Education*, held in Bangkok, Thailand, from 19 to 23 March 2007. This paper was awarded the UICEE Best Paper Gold (Third Grade) Award (decided as first place) by popular vote of Conference participants for the most significant contribution to the field of engineering education.

**As Director of the UICEE, Prof. Z.J. Pudlowski declined to accept the award, which was accepted by Ms D.Q. Nguyen.

However, the story is not all drastic as some engineering schools have responded enthusiastically by establishing and developing environmental engineering courses. There has been evidence of a growing number of environmental engineering programmes being established across engineering schools over the years; an implication, at least, that engineering is taking this environmental challenge seriously.

PROLIFERATION OF ENVIRONMENTAL ENGINEERING PROGRAMMES

In recent years, there has been a proliferation in the number of environmental engineering courses developed worldwide. This is evident by the growing demand and importance for this disciplinary area.

Safferman et al believe that most undergraduate environmental engineering programmes have come about largely due to the response from students or the community, and the strong interest from faculty [1]. In addition, there is a high demand coming from the environmental engineering market, which, according to Katcher, has also raised interest among engineering educators [2]. The increase in the number of environmental programmes has also come about due to the increased demand for more environmental training by students and employers of engineers [3]. Environmental engineering is, without a doubt, the most multidisciplinary of all the engineering fields and, perhaps, the most complex of them all.

Environmental engineering has emerged as a topic of interest among engineering educators since the 1970s and 1980s. This new field was still in its infancy stage during this period and very little was known about it. As time progresses, environmental engineering is slowly finding its niche in mainstream engineering. However, the interest for environmental engineering has fluctuated over the years and, more recently, has faded into the background. Environmental engineering is not receiving and attracting the same level of attention as it did when it first emerged in engineering in the early 1970s.

ENVIRONMENTAL EDUCATION AND ITS RELEVANCE IN ENGINEERING

The environmental debate has been going on for over four decades now and still continues to be a burning topic on the agenda, both politically and socially. Unfortunately, in engineering, the environment has only been discussed over a short period of time. There have been major discussions and talks about engineers needing to be educated about the environment, an area that has been neglected in past education.

Engineers are not only expected to have some form of environmental education but also to take an active role in helping to solve environmental problems. This idea has come about because engineers are seen as the problem and also as the solution to the environmental problems. Travers gives a good example of how engineers can fall into both categories [4].

Travers states that many of the environmental problems of the present have been made possible by technical developments for which the engineering profession has been at least in part responsible [4]. On the other hand, many of the solutions to the same problems are also technical and, again, within the responsibility of the engineer. Although this may sound simple in theory, it is harder to achieve in practice.

Further, according to Travers, this is because environmental problems are complex and require the application of knowledge and experience from a wide range of disciplines [4]. The current curricula are still very narrowly focused and little emphasis is placed on the environmental aspects. Although most agree and accept that engineers all need to be subjected to some form of environmental education, this requirement does not appear to be reflected strongly in existing curricula.

SUSTAINABLE ENGINEERING

In addition to this, engineers of today are pressured and encouraged to think and practice along this path of sustainable development, cleaner production, greener technology, ecological design, waste prevention and recycling, energy efficiency, resource conservation and environmental protection. All of these are key topics in the future of engineering development and fall into this new study area of environmental engineering.

Environmental engineering is undoubtedly an important area and will expand in the future as the environmental problems worsen. If this is the likely scenario facing the planet in the future, there will be a higher demand for more environmental specialists, namely: environmental engineers, to find solutions to environmental problems. Such achievements can only come about with proper education and training, and through a well-structured and designed curriculum in environmental engineering.

The field of environmental engineering can make a huge contribution to the overall engineering profession. Some of these benefits include: developing environmental technologies to solve environmental problems, improving the quality of life by conserving resources, improving efficiency for industry through recycling initiatives, raising the public image of engineers, contributing to global sustainability and finally, which is also very important, increasing the number of female engineers [5].

THE SUSTAINABLE MODEL

A model outlining the challenge of sustainability for engineers was proposed by Roberts. He pointed out the essential components requiring urgent attention by engineers if sustainability is to play an important role in engineering. These include issues ranging from resource development and recovery, processes, modification of resources and consumption patterns, environmental restoration, energy use, and production and the transportation systems [6].

He also suggests two ways in which environmentally friendly approaches and sustainability can be achieved in engineering education. One way is to give all engineers some exposure to general education in the environment while retaining their specialist field of practice. The other suggestion was to take 25% of future engineers and train them as environmental generalists by providing them with a broader education, ranging from environmentalism, engineering, law, economics, humanities, etc [6].

Roberts' model of sustainability is shown in Figure 1 [6]. Thom stated that a new technical culture has emerged in engineering and this requires a major transition towards cleaner production, energy efficiency and sustainable technologies in engineering [7]. In his work, Messerle has also emphasised the importance of sustainable development in engineering education [8].

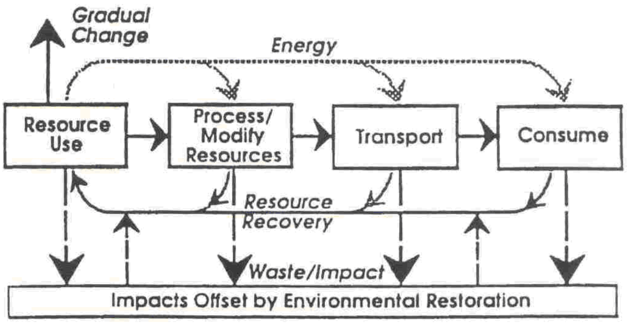


Figure 1: The model of sustainability proposed by Roberts [6].

Varcoe elaborates on the important issue of global sustainability and how engineers can contribute to this new challenge [5]. To achieve this, engineers need to take the following issues into consideration:

- Resource consumption/process efficiency;
- Energy resource availability – renewable versus non-renewable;
- Material resource availability – recyclable versus consumable;
- Life of the item or project;
- Ultimate disposal, completion or closure;
- Future use;
- Impact on the present community;
- Impact on future generations;
- Pollution and waste products;
- Recyclables [5].

THE INCEPTION AND RECOGNITION OF ENVIRONMENTAL ENGINEERING

Unlike other conventional engineering disciplines, environmental engineering has only been truly recognised and accepted as a separate engineering field in the last decade or so. Most environmental engineering programmes in the USA began in the mid-1970s and much later in Australia. In fact, the very first environmental engineering programme was introduced in Australia in the early 1990s.

Most programmes in environmental engineering stem from civil engineering or sanitary engineering; this is the main reason why it is so rare to find an environmental engineering programme without reference or linking it back to the civil or chemical engineering discipline. Unfortunately, as a result of this, many environmental engineering programmes suffer because most of the time, essential environmental subjects are overshadowed by subjects mostly from the civil engineering field. It is suggested that one way to overcome this problem is to design environmental engineering courses from scratch. This means not building it or relying on any existing civil/chemical engineering curricula. This particular approach helps to keep a programme independent and prevents it from being biased by one particular speciality or department [1][9].

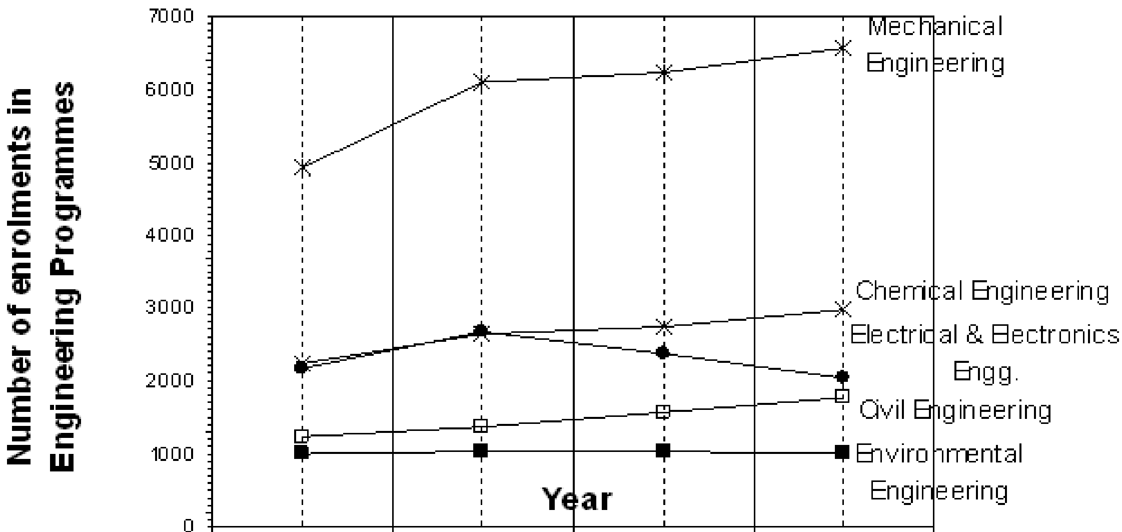
NATIONAL STATISTICS OF ENROLMENTS IN ENGINEERING COURSES FROM 2001-2004

Figure 2 presents the national enrolments of both domestic and international students in five main engineering disciplines in Australia during the academic years from 2001-2004 [10]. According to this chart, it is seen that the enrolments in these engineering disciplines are steady, although with minor fluctuations in the number of enrolments observed in some areas of engineering. It should be noticed that mechanical engineering is the most attractive among students, drawing in the highest number of students, with chemical engineering attracting the second highest number of students.

HISTORY OF ENVIRONMENTAL ENGINEERING

There was a series of environmental engineering education conferences held between the 1960s and 1980s at various universities. The very first conference was held at Harvard University, a prestigious university in the USA, to mark the importance and open up discussions concerning this new discipline in engineering. This so-called new discipline was known at the time as *sanitary engineering* and, by 1973, this term was officially changed and renamed to environmental engineering. The changing of the name was necessary in recognition of the rapid evolution of undergraduate programmes in environmental engineering and also due to the broadening of the scope of the underlying field [11].

The adverse effects of environmental pollution on human health were first identified and found to be



	2001	2002	2003	2004
Chemical Engineering	2239	2650	2755	2996
Civil Engineering	1249	1366	1569	1781
Electrical & Electronics Engg.	2165	2665	2376	2040
Environmental Engineering	1021	1049	1047	997
Mechanical Engineering	4921	6087	6245	6569

Figure 2: The changes in the national enrolments in five engineering disciplines (2001-2004) [10].

linked to water-borne pollutants. Civil engineers during this period were the professionals responsible for building sewers and public waterworks to improve the sanitation and hygiene of those cities affected by the spread of these water pollutants. The practice of this area was then called *sanitary engineering* and it is more commonly known today as water quality engineering [11]. Due to the early work performed by civil engineers in sanitation, the study area of sanitary engineering still remains a strong part of civil engineering education and programmes.

The environmental engineering profession and discipline were basically non-existent in the past and therefore civil engineers were assumed as fulfilling the role of environmental engineers.

In the early 20th Century, air pollution from combustion processes and the production of chemical smog became a major concern, which resulted in the increased involvement of other engineering professions, particularly chemical and mechanical, in tackling air quality problems. During this period, a few institutions began establishing and offering programmes in air pollution control in chemical engineering departments [11]. It should be quoted at this point that:

> *Thus, in the early evolution of environmental engineering education, the civil engineering component predominated, with program enrichment resulting from cross-over, primarily from chemical and some mechanical engineering faculty* [11].

As a result of this early evolution of environmental engineering education, the same ideology has also been followed and embraced in today's environmental engineering programmes. It is true to say that most environmental engineering programmes today are predominantly created from existing civil engineering programmes, which is not always the best option as many problems have derived from this association. It is also noted that current environmental engineering education is not only limited to studies relating to air or water quality engineering, as was the case in the past, but has expanded to be much wider in scope. This is evidence that environmental engineering is growing and expanding into a field of its own.

Between 1971 and 1977, there was a rapid increase in enrolments in undergraduate environmental engineering degree programmes and also in the number of institutions offering environmental engineering programmes across the USA [11]. It was not until the 1990s that environmental engineering became renowned and found its niche in engineering schools at Australian universities. Patterson stated that several earlier programmes offered in institutions across the USA shared many common characteristics [11]. The opposite finding is noticed in today's environmental engineering programmes. There appears to be no uniformity or consistencies with the content matter and development of environmental engineering programmes at the global level.

According to Patterson:

> *… the past two decades, 1960-80, have been a period of transition for the environmental engineering profession and for university programs in environmental engineering* [11].

ENVIRONMENTAL ENGINEERING EDUCATION CURRICULA IN THE PAST

The mean distribution of subjects obtained from 15 institutions in the USA in 1977 that offered baccalaureate degrees in environmental engineering is presented in Figure 3 [11]. It is clear from the data gathered in this study that there was very little emphasis on environmental science and study on the environment. It could be concluded that environmental engineering in the past was more science/engineering orientated when compared to current environmental engi-neering education. It demonstrates that for the most part of the curriculum about 70% of the content is comprised of science studies and the remaining part is dedicated to non-technical studies.

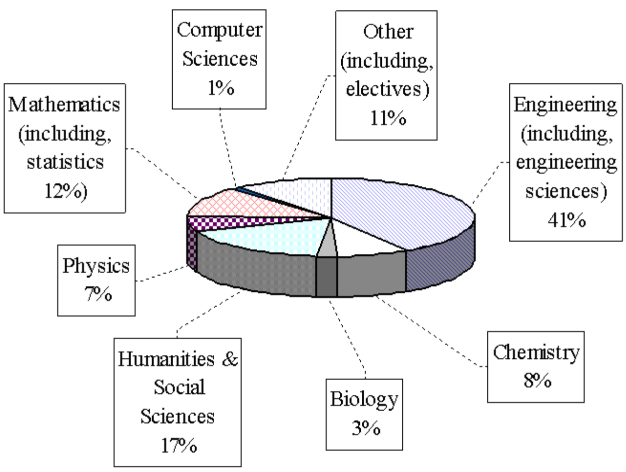


Figure 3: The mean distribution as a percentage of specific subject areas in environmental engineering education programmes in 1977 [11].

The mean distribution as a percentage of subject areas listed in ascending order includes:

- Engineering (including engineering science) (41%);
- Humanities and social sciences (17%);
- Mathematics (including statistics) (12%);
- Other (including electives, thesis) (11%);
- Chemistry (8%);
- Physics (7%);
- Biology (3%);
- Computer science (1%).

In order to acquire a better understanding of other subjects included in past environmental engineering curricula, the pie chart shown in Figure 4 is a combination of specific subject areas, including those listed under the general category of *other areas*, which gives a total of 48%.

ENVIRONMENTAL ENGINEERING EDUCATION TODAY

It would be fair to say that the scope of environmental engineering education in the past was more narrowly defined and the curricula appeared to be more compact, whereas the scope of environmental engineering today is much more diverse and broader.

The common environmental engineering specialties, as expressed by representatives from academia, the government and industry in a study conducted in the USA, include:

- Wastewater, storm water and water treatment;
- Solid waste management;
- Air pollution control;
- Hazardous waste remediation;
- Waste minimisation and pollution prevention;
- Risk assessment and safety engineering [1].

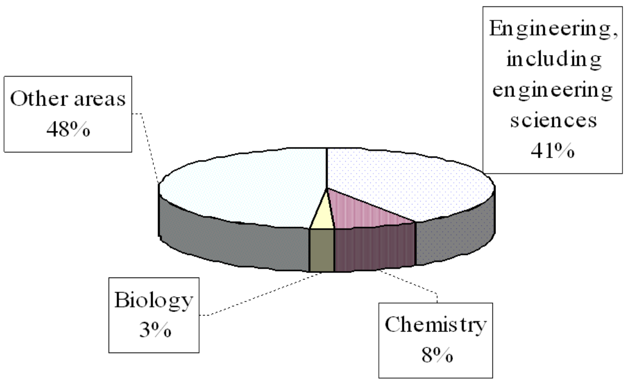


Figure 4: The mean distribution as a percentage of general subject areas in environmental engineering education programmes in 1977 [11].

These specialties mentioned in the survey are commonly found in most environmental engineering programmes. However, since its inception, environmental engineering has expanded in scope and it has become necessary to include issues like sustainable development, recycling, cleaner production and Life Cycle Analysis (LCA) in the curricula.

When again referring to Figure 2, which illustrates the enrolments of students in engineering programmes in Australia during the academic years of 2001 to 2004, the following points can be drawn from this line graph:

- Engineering appears to be a reasonable choice of study at universities among school leavers;
- The national number of intakes in engineering courses in recent times has been steady;
- There has been a slight decline in the number of enrolments of some engineering disciplines over others, but overall, the enrolment numbers in engineering courses are stable;
- Enrolment numbers in mechanical engineering, chemical engineering and civil engineering have steadily increased;
- There has been a slight drop in enrolment numbers in electrical and environmental engineering courses observed over the consecutive four years, but this is not a significant number [10].

THE ATTRACTION OF WOMEN TO ENVIRONMENTAL ENGINEERING

As stated earlier, environmental engineering has evolved from sanitary engineering, which is a field predominantly found in civil engineering. Figure 5 shows the national enrolment of females in engineering courses in Australia (2001-2004). What is surprising about Figure 5 is that civil engineering programmes have not been particularly successful in attracting and retaining female students to its course [10].

It is highlighted in Figure 5 that environmental engineering courses appear to be more successful in attracting female students when compared to the intake of female students from other classical engineering disciplines, such as courses in mechanical engineering. The field of environmental engineering, closely followed by chemical engineering, is the preferred choice among female students. As shown in Figure 5, environmental and chemical engineering attract approximately 40% of the female population to their courses [10].

What is the reason behind this attraction? Perhaps environmental engineering is more appealing to the female gender because it touches on the softer issues of engineering or so-called *soft engineering* as opposed to *hard engineering*.

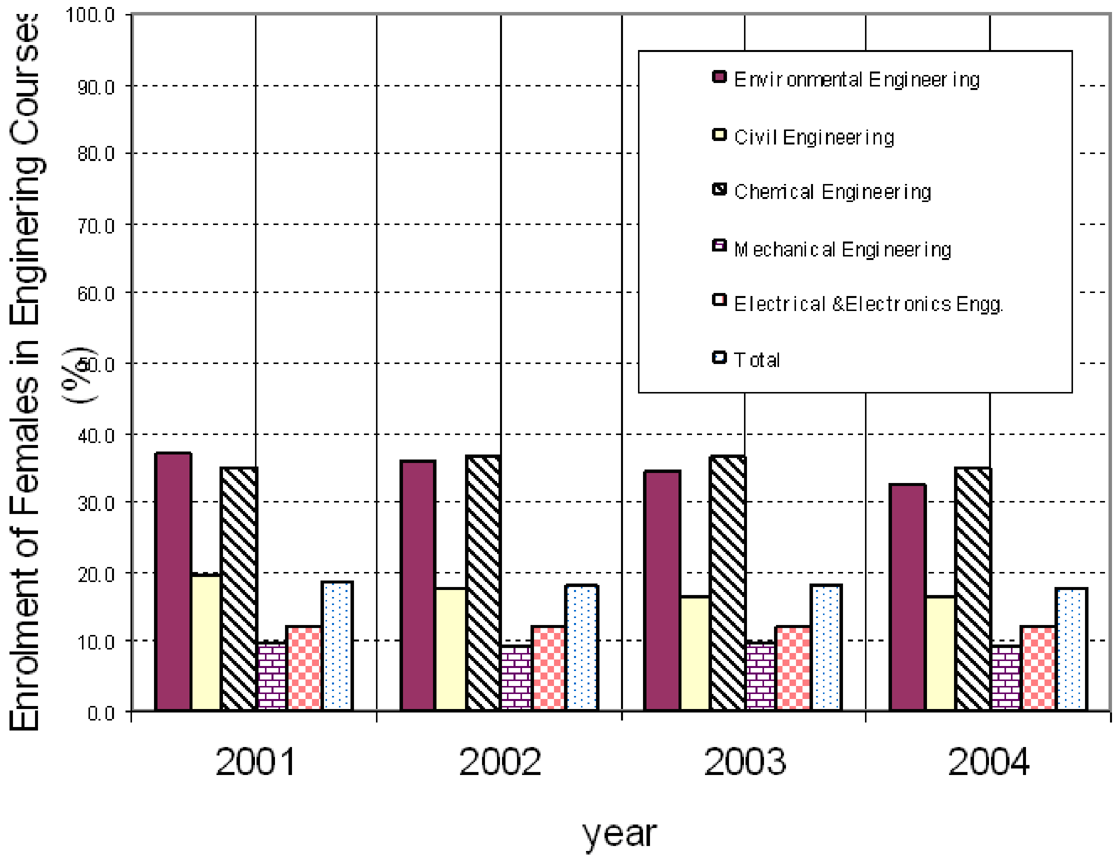


Figure 5: The national enrolment of females in engineering courses (2001-2004) [10].

As the statistics confirm, engineering is predominantly a male occupation. Hence, it is not surprising to find that 80% of the students enrolled in engineering courses in Australia are male. Women, who are in the minority, will always have difficulties fitting into the male-dominated and oriented structure. Therefore, something has to be done in order to remedy this situation.

There have been many discussions over the years among engineering educators, particularly female educators, on how to increase the population of women in engineering courses and make it more appealing for women. One option to consider may be to integrate the environmental aspects into general engineering curricula. The challenge here, of course, is finding the availability of space in the already limited and overcrowded engineering curricula.

Although the Australian national data has revealed that chemical engineering is a popular choice among females, the opposite finding was surprisingly reported in most countries of the European Union (EU) [12].

In Australia, of the five classical engineering fields, programmes in mechanical engineering appear to be the least appealing to female students, attracting less than 10% of the female population. On average, engineering courses attract about 20% of the female population. This reaffirms the statement made earlier in the article about engineering being a male-oriented discipline.

Similar findings were also reported in most countries of the EU. It was reported that females represent about 25% of the total number of enrolments in engineering courses [12].

This number is still very small in comparison with the number of women enrolling in science courses, especially in the humanities and social sciences courses. It is clear that more work is needed to increase the participation of women in engineering.

ISSUES OF CURRICULA DESIGN

The task of designing curricula, particularly engineering curricula, is not a simple one, but is essential in the formation of professional engineers. What academics should remember in designing any engineering curricula is that most undergraduate degrees must be developed within this confined period – usually within four years in many parts of the world. Hence, in order to design a curriculum for such a short and restricted period, it is imperative that the fundamental core modules be identified and included in this four-year structure.

As a general comment, academics must not fall into this trap of including everything into environmental engineering curricula because a bit of everything could result in absolutely nothing. This is a typical case of too much of everything and not enough of anything. This is one of the prevailing problems noted with most environmental engineering curricula today [13]. Moreover, it is unrealistic and overly ambitious to think that everything can be covered in detail in a four-year programme. Apart from the issue of the balance of content in the curriculum, several other problems associated with environmental engineering have been discussed and highlighted by the authors elsewhere [9][14].

Environmental engineering, like any other engineering discipline, should have its own identity and merits, and the content of an environmental engineering curriculum should facilitate the establishment of a solid foundation in relevant studies pertaining to the field of environmental engineering. It should not be developed as a derivative of civil or chemical engineering as this evidently was the case in past times.

The first stage in designing environmental engineering curricula is to identify and determine the fundamental core modules to be included in the curriculum. Once those main modules are identified, it is relatively easy to build a curriculum by adding other relevant modules. It should be emphasised that the difficult part is to identify those core modules and arrange them, for instance, by the use of a modern methodology, eg the Modelling Method [15].

In this endeavour, the optimum objective is to design a curriculum that will produce graduate environmental engineers with the appropriate skills, knowledge and attributes to enable them to work, function and carry out their duty as professional engineers.

THE RELATIONSHIP BETWEEN ENVIRONMENTAL ENGINEERS WITH OTHER PROFESSIONS

It has been asserted that environmental engineers are of a hybrid of an engineer and a scientist, thus making them the best profession to deal with environmental problems. Indeed, this view is illustrated by Reible, where he forms a relationship and the connection of environmental engineers with other professions in similar roles (see Figure 6) [3].

Therefore, the work of an environmental engineer involves comprehensive knowledge and understanding of both the engineering (eg chemical, civil, materials, mechanical engineering, etc) and science (eg biology, chemistry, environmental science, etc) disciplines. This just emphasises the broadness of this field. This multidisciplinary requirement may be viewed as a serious problem in the environmental engineering

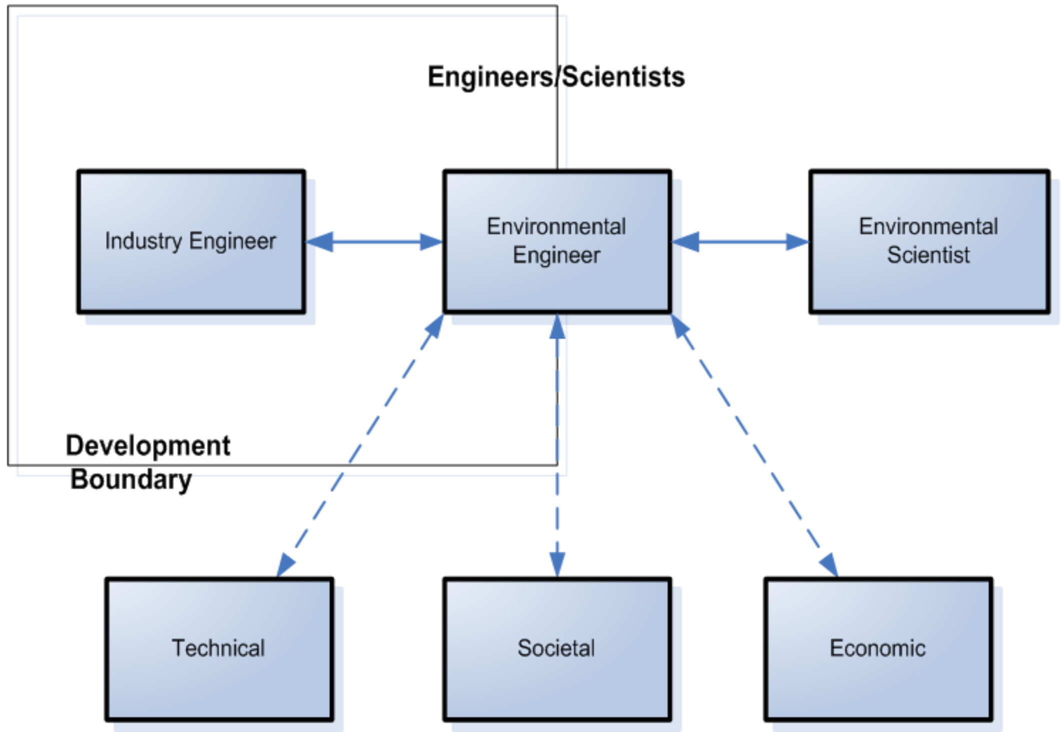


Figure 6: The relationship of environmental engineers with other professions working within the technical, societal and economic constraints [3].

profession as those engineers may be expected to acquire and display similar knowledge and experience of practising engineers of other fields namely, chemical, civil and mechanical engineers, as well as be knowledgeable in the science field [3].

CONCLUSION

Environmental engineering has grown, expanded and evolved into quite a unique area of engineering since its inception in the early 1970s. The curricula content and the distribution of subject matter have changed substantially since then. The scope of current curricula is more diverse, multidisciplinary and complex, and perhaps is presently lacking consistency when compared with past curricula.

The other special feature of environmental engineering is that it can be successful in recruiting women to its courses, which helps break down this gender barrier found in other engineering courses, such as mechanical and electrical engineering. Generally speaking, the number of women studying engineering is still a record low at 20% in Australia and 25% in most countries of the EU.

What is then the future status of environmental engineering? It is the authors' strong conviction that environmental engineering education firstly needs to be internationalised or globalised to resolve this imperative issue of accreditation and recognition of qualifications. For environmental engineers to be truly recognised, being able to move freely across national settings and work across national borders, recognition and accreditation need to be resolved by establishing some form of standardisation and/or harmonisation in the education system so that it fits into global education standards. One way of achieving global standards may be through the use of a global curriculum [9].

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BIOGRAPHIES

Dianne Q. Nguyen graduated with a Bachelor of Applied Science, majoring in chemistry and environmental management, from Deakin University, Australia, in 1994, and then completed her Honours year in 1997 and Masters in Engineering Science (Research) at Monash University, Australia, in 2000.

She has spent time working in research laboratories before entering academia. Since December 1995, she has been with the UNESCO International Centre for Engineering Education (UICEE) in the Faculty of Engineering at Monash University, Melbourne, Australia. She is currently a Research Fellow and finalising her PhD in environmental engineering education.

Her special research interests include environmental engineering, engineering education, sustainable engineering, global education, curriculum analysis and design, statistical analysis, research methods, and women in engineering. Also, she has external interests in Web design and programming in Java and Javascript. In her spare time, she enjoys doing high impact aerobics, weight training, tae-box and reading. Her hobbies include fashion, shopping, computers, travelling, playing music, playing golf and watching movies.

Her awards include: UICEE's *Women in Engineering Education Scholarship* (1997-2000); the UICEE Silver Badge of Honour for her contribution to engineering education and to the operation of the UICEE (1998); the UICEE Best Paper Diamond (First Grade) Award for a distinguished contribution in delivering an outstanding paper to the *Global Congress on Engineering Education* (July 1998); the UICEE Best Paper Silver (Fourth Grade) Award at the *8th Baltic Region Seminar on Engineering Education* (September 2004); the UICEE Best Paper Diamond (First Grade) Award at the *9th UICEE Annual Conference on Engineering Education* (February 2006); the UICEE Best Paper Gold (Third Grade) Award (first place) at the *10th UICEE Annual Conference on Engineering Education* (March 2007); and her latest award, the UICEE Best Paper Diamond (First Grade) Award at the *11th Baltic Region Seminar on Engineering Education* (June 2007). She is also a recipient of the prestigious *Australian Postgraduate Award* (October 2000-October 2003), Monash Departmental Award (October 2000-October 2003) and Monash Travel Grant (October 2001).

She has also served on several national and international engineering education conference organising committees. She has already published close to 50 conference and journal papers.

Ms Nguyen is the current Treasurer of the International Liaison Group on Engineering Education (IL-GEE).

Zenon Jan Pudlowski graduated Master of Electrical Engineering from the Academy of Mining and Metallurgy (Kraków, Poland), and Doctor of Philosophy from Jagiellonian University (Kraków), in 1968 and 1979, respectively.

From 1969 to 1976, he

was a lecturer in the Institute of Technology within the University of Pedagogy (Kraków). Between 1976 and 1979, he was a researcher at the Institute of Vocational Education (Warsaw) and from 1979 to 1981 was an Adjunct Professor at the Institute of Pedogogy within Jagiellonian University. From 1981 to 1993, he was with the Department of Electrical Engineering at The University of Sydney where, in recent years, he was a Senior Lecturer.

He is presently Professor and Director of the UNESCO International Centre for Engineering Education (UICEE) in the Faculty of Engineering at Monash University, Clayton, Melbourne, Australia. He was Associate Dean (Engineering Education) of the Faculty of Engineering between 1994 and 1998.

In 1992, he was instrumental in establishing the International Faculty of Engineering at the Technical University of Lodz, Poland, of which he was the Foundation Dean (1992-1995) and Professor (in absentia) (1992-1999). He was also appointed Honorary Dean of the English Engineering Faculty at the Donetsk National Technical University in the Ukraine in 1995.

His research interests include circuit analysis, electrical machines and apparatus, implementation of computer technology in electrical engineering, software engineering, methodology of engineering education and industrial training, educational psychology and measurement, as well as human aspects of communication in engineering. His achievements to date have been published in books and manuals and in over 350 scientific papers, in refereed journals and conference proceedings.

Professor Pudlowski is a Fellow of the Institution of Engineers, Australia, and of the World Innovation Foundation (WIF), UK. He is a member of the editorial advisory board of the *International Journal of Engineering Education*. He is the founder of the Australasian Association for Engineering Education (AAEE) and the *Australasian Journal of Engineering Education* (AJEE), and was the 1st Vice-President and Executive Director of the AAEE and the Editor-in-Chief of the AJEE since its inception in 1989 until 1997. Currently, he is the Editor-in-Chief of the *Global Journal of Engineering Education* (GJEE) and the *World Transactions on Engineering and Technology Education* (WTE&TE). He was on the editorial boards of the *International Journal of Electrical Engineering Education* (1993-2005) and the *European Journal of Engineering Education* (1993-2005). Prof. Pudlowski was the Foundation Secretary of the International Liaison Group for Engineering Education (ILG-EE) (1989-2006) and is currently its Chairman.

Professor Pudlowski was a member of the UNESCO International Committee on Engineering Education (ICEE) (1992-2000). He has chaired and organised numerous international conferences and meetings. He was the Academic Convener of the *2nd World Conference on Engineering Education*, the General Chairman of the *East-West Congresses on Engineering Education*. He was also General Chairman of the *UNESCO 1995 International Congress of Engineering Deans and Industry Leaders*, and General Chairman of the *Global Congress on Engineering Education*, to name a few.

He received the inaugural AAEE Medal for Distinguished Contributions to Engineering Education (Australasia) in 1991 and was awarded the Order of the Egyptian Syndicate of Engineers for Contributions to the Development of Engineering Education on both National and International Levels in 1994.

In June 1996, Prof. Pudlowski received an honorary doctorate from the Donetsk National Technical University in the Ukraine in recognition of his contributions to international engineering education, and in July 1998, he was awarded an honorary Doctorate of Technology from Glasgow Caledonian University, Glasgow, Scotland, UK. He was elected a member of the Ukrainian Academy of Engineering Sciences in 1997. In 2002, he was awarded the title of an Honorary Professor of Tomsk Polytechnic University, Tomsk, Russia, and was an External Professor at Aalborg University, Aalborg, Denmark (2002-2007). He is listed in 14 *Who's Who* encyclopaedias, including the Marquis *Who's Who in the World*. He has been recently appointed to the Register for External Reviewers of the Oman Accreditation Council (OAC).

Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

Important Considerations in Improving the Acquisition of Communication Skills by Engineers*

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Communication skills, as discussed in this article, are considered from the point of view of linguistics, communication channels and patterns for engineers, as well as strategies for effective communication and the re-evaluation of engineering curricula that must be incorporated in engineering courses in order to enhance communication-related outcomes. Therefore, it is the intention of the authors to reflect on communication skills for engineers, which are so critical for professional success and, hence, so necessary to be an integral part of engineering education. It is a well-known fact that demand breeds supply. With a constantly growing number of commercial courses like *English for Engineers* or *Communication Skills for Engineers*, which are designed to help engineers to communicate effectively in English, there is no doubt that something is missing in engineering and technology education. Many engineering educators, as well as industry leaders, strongly advocate for the inclusion of the development of the so-called *soft skills* in engineering curricula. This comes from the application of modern technologies and industrial processes, as well as the globalisation of professional and business activities, which have caused a great impact on engineering that demands from engineering graduates well-developed communication skills in native and foreign languages.

INTRODUCTION

Us engineers don't need no English is a phrase that, according to Herbert Hirsh, was common in engineering circles. The idea behind the words was popular both among students and staff, who strongly believed that it was more important and interesting to be advanced in terms of technological subjects rather than have a *radical departure* towards something like English and communication [1].

Despite further advancements and innovations in the modern world, when dynamic technological changes fill in both reality and cyberspace, thus giving more opportunities and excitement for young aspiring engineers, technologists and scientists to be closer to technological wonders, as well as providing them with mobility, nothing seems to change in the attitude towards English and communication skills acquisition.

There is still a trend to take English and communication subjects as something less significant than technological disciplines. Although becoming more technological and complex, engineering work requires communication to be more technological and complicated.

A NEED TO HONE COMMUNICATION SKILLS

Does knowing a language well guarantee its successful usage with real communication impact? Is communication all about mastering the grammar and having a decent scope of vocabulary? How far should one try to expand his/her vocabulary in order to communicate efficiently?

It has been shown by extensive research in applied linguistics that a comparatively limited number

*A revised and expanded version of a paper presented at the *11th Baltic Region Seminar on Engineering Education*, held in Tallinn, Estonia, from 18 to 20 June 2007. This paper was awarded the UICEE Best Paper Silver (Fourth Grade) Award by popular vote of Seminar participants for the most significant contribution to the field of engineering education.
**As Director of the UICEE, Prof. Z.J. Pudlowski declined to accept the award, which was accepted by Mrs E.A. Danilova.

of words is needed to be able to communicate effectively in any language. It is advocated that for all purposes of communication, only about 2,000 different words are required. This small number of words, compared with what is included in recent editions of dictionaries, if used grammatically correct and context-wise, will serve all communication purposes, but will not make a successful communicator.

As long ago as in 1910, Joseph Devlin, in supporting this statement, wrote in the book *How to Speak and Write Correctly* the following:

> *... a great many people who pass in society as being polished, refined and educated use less* [than 2,000 words]*, for they know less. The greatest scholar alive hasn't more than four thousand different words at his command, and he never has occasion to use half the number* [2].

A successful communicator is not the one who can produce sentences grammatically correct; who is able to be fluent, linguistically elegant and expressive, and even not the one who has a native-speaker insight of how the language works, but the one who is able to get the message across to a listener.

Today, it is often believed that a typical engineering graduate lacks communication skills. Cerri states the following:

> *Very few engineers even believe that communication is an issue for them until they are in the work environment and are faced with what seems to be an inability to connect with and influence people. For the typical engineering student, effective communication skills are assumed to come along as a process of human maturation* [3].

If this is the case, then the lack of communication skills can be the cause for young engineers to be greatly disadvantaged in terms of career advancements and further professional achievements and perspectives. Those born or well-trained communicators can easily craft their role towards senior managerial positions being able to promote their ideas, obtain better funding for projects, achieve better results and feedback, and, as such, promote themselves and gain recognition. Amazingly, while technological in nature, the engineering profession is highly communicative in practice.

According to *King Research*, numerous proprietary studies performed in various organisations from the 1980s to the 1990s aimed at determining the communication activities of professionals found that engineers and scientists spend the majority of their time communicating [4].

Gunn claims that *without communication there is no engineering* [5]. Indeed, any product or process of engineering is based on communication at any stage of its development. Hence, communication predetermines and directly affects the success or failure of any engineering undertaking.

It was also documented that a professional engineer will spend up to 80% of the time communicating with other engineers, clients and the general community [6].

Very interesting research was done by Raitt, which showed the distribution of time spent by European Aerospace engineers on various communication channels as presented in Table 1.

About a hundred respondents participated in this survey, which showed that engineers were actively involved in various forms of communication. Each form of workplace communication draws on various communication skills. No matter what the form is, it looks like the reality itself; not only work description dictates the need to develop CQ – Communication Quotient – in order to be qualified as a professional. Indeed, effective workplace communication is essential for personal and professional success; therefore, CQ enhancement has to be in the curriculum of any engineering programme.

It is very important that students master the tools, techniques and strategies on how to capitalise on the existing skills in accordance with the personality type, learn how to engage in and build professional relationships elegantly, as well as to be able to gain rapport with others in order to realise positive outcomes.

In their research to find appropriate communication patterns for engineers, Tenopir and King also underlined the following:

> *Engineers are rarely taught advanced techniques of information retrieval, however, and are typically not naturally gifted communicators, making it difficult to fill their complex information needs (which can then impair their ability to produce high-quality work)* [4].

It is assumed to be very important for engineers to determine their information needs, find the appropriate means to satisfy them, refine the information, be able to present their results, and adjust and enhance things after obtaining feedback. Only those specialists who are able to manage the existing information

Table 1: The level of time in percentage spent by engineers on communication [7].

Communication Channels	Level of Time (%)		
	Little	Quite a lot	Very much
Oral, formal			
Staff meetings	66	27	7
Contractor meetings	43	39	18
Presentations	77	22	1
Progress meetings	46	41	13
Brainstorming sessions	74	19	7
Committee meetings	77	19	4
Oral, informal			
Corridor talks	69	23	8
Canteen talks	84	15	1
Impromptu visits	38	39	24
Sports/social phone	38	40	22
Written			
Letter	50	41	9
Memo/telex	28	55	17
Internal report	36	49	15
Conference paper	77	19	4
External paper/article	82	12	5
Giving documents	59	32	9

and effectively convey their innovative courageous ideas, concepts and values will have a specific professional influence on their colleagues and customers, thus being able to ignite the progress in science, technology and manufacture.

As stated by Tenopir and King:

> *Not only is information an essential resource for performing engineering activities, but the principal output from these activities is information in one form or another* [4].

The communication framework for engineers and various communication channels used in their professional activities is depicted in Figure 1.

In the centre of the engineers' communication cycle are the main work activities performed by engineers, such as research, design, teaching, administration, etc. In order to fulfil these tasks, an engineer

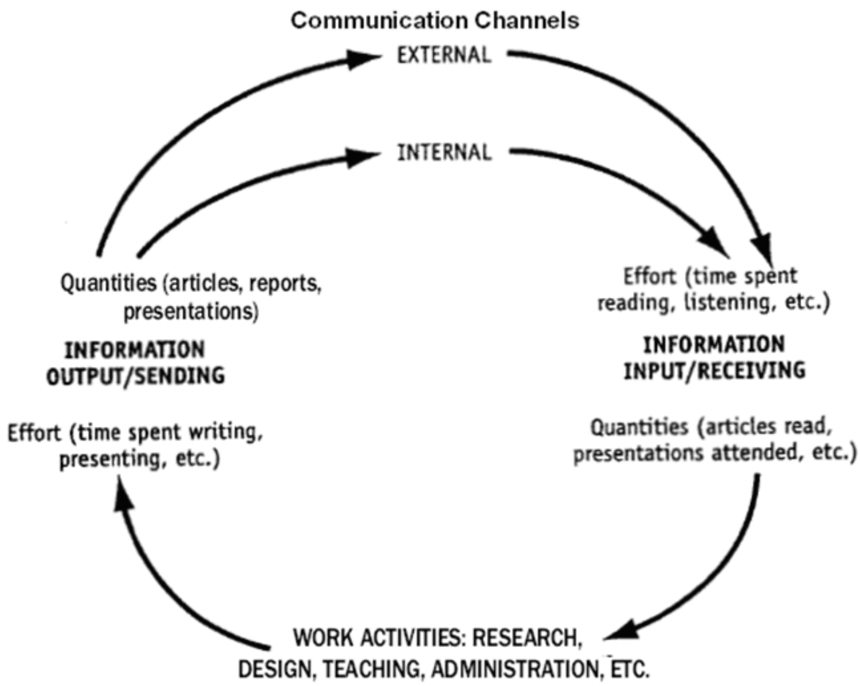

Figure 1: The engineers' communication cycle [4].

should make an effort and spend some time preparing an output of information in written, graphical or oral forms. The next step is to get the message across effectively and efficiently through internal or external channels, ie among the colleagues or clients, committees, experts, etc. Receiving the information also requires effort and time to be spent on reading or listening. Later, the received information requires a thorough analysis and synthesis after which it returns to support and enhance research, design, teaching, administration, etc.

Information output from engineering work involves interpersonal (oral and written) channels of communication. Interpersonal communication involves such channels as informal discussions, advice and consultations, research and presentations, proposals and plans, formal workshops, seminars, trainings or classes. Written communication channels cover such areas as formal publications intended for external audiences, for example, scholarly and trade articles, conference proceedings, books, patent documents, as well as technical reports, proposals or plans that may be created both for internal and external audiences. The target audience may be internal or external, but it is envisaged that engineers tend to communicate more internally than externally [4].

An internal audience may be more supportive and open towards the outputting ideas, excluding the cases when there is an internal interpersonal tension or dislike of the presenter. In this case, the presenter has to have the art of shifting the accent of the audience from his/her personality to the message he/she is delivering.

By the same token, George Bernard Shaw once concluded: *The single biggest problem with communication is the illusion that it has taken place* [8].

It happens because communication is a very complicated process that is conditioned to success only when all the co-participants take active part in the process of formulating and interpreting messages. Krauss states that:

> *At a fundamental level verbal messages convey meanings the speaker has encoded into the words of an utterance, but a listener who has understood the utterance has gone beyond the literal meaning of the words and grasped the particular sense in whish the speaker intended them to be understood* [9].

Any communicative exchange is a joint activity where the meaning emerges as a result of participants' collaborative efforts.

Communication is defined by Canale as:

> *... the exchange and negotiation of information between at least two individuals through the use of verbal and non-verbal symbols, oral and written/visual modes, and production and comprehension processes* [10].

Further, he also lists the following characteristics of communication:

- A form of social interaction;
- Involving a high degree of unpredictability and creativity;
- Taking place in discourse and sociocultural contexts that constrain appropriate language use;
- Limited by psychological constraints;
- Having a purpose;
- Involving authentic language being judged as successful or not by the achievement of the communicative purpose [10].

Another interesting definition of communication may be equally good for describing the working principle of a fax machine. Anthropologists Daniel Sperber and Denise Wilson characterise communication as:

> *... a process involving two information-processing devices. One device modifies the physical environment of the other. As a result, the second device constructs representations similar to the representations already stored in the first device* [11].

In human communication, *information processing devices* stand for people involved in a conversation, *physical environment of a device* is a uniquely human capacity to produce and perceive speech, and the *representations* are mental representations or ideas. Hence, communication is about being on the same wavelength in order to make the information flow smoothly from the source to the destination.

In their intent to have a clearer understanding of human communication process, scientists tried to illustrate it as if it was a physical model based on the natural structure of a language and how human brain processes verbal and non-verbal information. It gave the opportunity to see communication as a more or less predictable, closed system with input, output and feedback [3].

The acceptance of such a communication model has made it possible to determine its components to be able to teach them to students so that they could discover their unique communication style and develop assertive communication techniques. These studies also helped to figure out the so-called communication pitfalls that either boost or obstruct the effectiveness of communication during which both the speaker and the listener perform verbal and mental activities. The model takes into account that:

> *These mental and verbal processes are deletion, distortion, and generalization. Deletion is the elimination of useful or important information. Distortion is the process of changing the meaning of a communication. Generalisation is the expansion of a communication message to include other, unrelated applications. These three communication* violations *impede effective communication because they change the resulting communication into something different than originally intended. By understanding the roles of deletion, distortion, and generalisation, communicators can remove the negative effects of these three processes* [3].

Communication is all about not to be heard but to be properly understood. Therefore, if communication does not take place or is distorted on the way to the listener, the speaker has to take the responsibility as he/she is the only one who knows exactly what meaning is being conveyed by the message he/she wants to deliver. Communication skills go far beyond being able to present ideas clearly, link sentences into logical utterances and understandable messages; it is also about interpersonal space awareness, time control, body language, eye contact, cultural peculiarities and even the tone of the voice. It looks like a real art but it can be mastered or nicely performed.

SPICING ENGINEERING WITH LINGUISTICS

There have been many discussions generated about the need to develop communication skills and enhance the so-called communicative competence of engineering students. It was curious to have some insights of what, in fact, is a communicative competence. It was discovered that the definition of this notion is full of controversy and theoretical inconsistency.

In 1965, Chomsky, who was the first to raise this issue among linguists, defined competence as *the speaker-hearer's knowledge of his language*, and performance was described as *the actual use of language in concrete situations* [12]. What is being addressed by Chomsky as competence (ie the knowledge of grammar, syntax, phonology, vocabulary, etc) looks like grammatical or rather linguistic competence, while performance (ie the skills to communicate the ideas and keep the transmission of information among those involved in a talk afloat) is being advocated today as communicative competence.

According to Hymes, communicative competence *is integral with attitudes, values, and motivations concerning language, its features and uses* [13]. The core of Hymes' idea is that grammatical competence is not enough to communicate effectively in a language. It is vitally important to know how language is used by members of a speech community to reach the communication purpose.

In the 1960s, Newmark expressed his dissatisfaction with the then prevailing foreign language teaching that was aimed at preparing *a structurally competent* student. One of his popular examples is about *a stranger asking for a light*. A structurally competent student can accurately manipulate the structure of the language by performing this task in the following ways:

- *Have you fire?*
- *Do you have illumination?*
- *Are you a match owner?* [14].

This example shows that what is grammatically correct does not always justify the purpose of communication as the above mentioned grammatically accurate sentences would not be used by native speakers in order to ask for a light. Along these lines, Hymes is absolutely right by stating that *there are rules of use without which the rules of grammar would be useless* [15].

Canale and Swain made a seminal effort to define communicative competence as the integrity of the following four components [10][16]:

- *Grammatical competence* was seen to encompass *knowledge of lexical items and of rules of morphology, syntax, sentence-grammar semantics, and phonology* [16];
- *Discourse competence* was defined as the ability to connect sentences in stretches of discourse and to form a meaningful whole out of a series of utterances;
- *Sociolinguistic competence* was defined as involving knowledge of the sociocultural rules of language and of discourse;
- *Strategic competence* was seen to refer to *the verbal and nonverbal communication strategies that may be called into action to compensate*

for breakdowns in communication due to performance variables or due to insufficient competence [16].

It should be noticed that traditional language teaching was basically the development of grammatical competence, whereas the modern approach to language teaching is mostly the enhancement of discourse competence. Unfortunately, in the majority of cases, sociolinguistic and strategic competences are still neglected.

It is advocated that all four components are of great importance and have to be enhanced in order to help learners achieve communicative competence. Nevertheless, communicative competence is not enough for efficient communication.

It is also very important to distinguish the fundamental difference between such notions as *communicative competence* and *communicative performance*. Communicative competence is the tacit or internalised knowledge of the language, ie relationship and interaction between grammatical, discourse, sociolinguistic and strategic competences. Communicative performance can be defined as external evidence of language competence or the actual use of the language and realisation of all these competences in various situations.

Even in the world of animals, the ability to communicate is considered as vital for survival, not to mention professional habitat of Homo sapiens.

All animal species communicate, with some being impressively proficient and accurate in delivering the message across. Nevertheless, none of the animal species achieves the precision and flexibility that characterises human communication, a capacity due, in large part, to the uniquely human ability to use language [17].

It is, therefore, envisaged that communication skills for engineers can be enhanced through language teaching and learning by means of developing communicative competence with special practical activities designed to foster communicative performance. Being quite specific, engineering communication skills should be improved on the basis of specific context with relevant types of engineering activities, which can be naturally conveyed by an appropriately designed course of English for Specific Purposes (ESP).

It should be emphasised that designing curricula and developing syllabi content is only halfway to successfully improving engineering communication skills. It is the responsibility of teachers to create conditions, use innovative approaches and appropriate techniques, and offer such learning activities that would create a proper environment for engineering students to favour communication.

As far back as 1981, Brumfit stated the following:

What makes learning communicative *is not only a matter of teaching and learning content but a methodology which provides opportunities for the learners to learn a second or foreign language in use* [18].

For over three decades, the Communicative Language Teaching (CLT) approach has served to satisfy this need. CLT is characterised by a shift from focusing on the language itself to emphasising the expression and comprehension of meaning through the language use.

Compared to approaches that are primarily or even exclusively form-focused and metalinguistic in orientation, CLT is designed to engage learners in the pragmatic, functional and authentic use of the target language for meaningful purposes; indeed, it does a better job of leading to higher levels of fluency and communicative confidence [19].

It would be desirable that a teaching methodology should implement broadly the elements of Neuro-Linguistic Programming (NLP). The reason for this choice is that NLP methodology is based on the concept of rapport and its primary objective is performance enhancement.

NLP lies in the sphere of modern psychology and is, in fact, a scientifically approved set of advanced communication skills. As stated by the magazine *Psychology Today*:

NLP cannot be dismissed as just another hustle. Its theoretical underpinnings represent an ambitious attempt to codify and synthesize the insights of linguistics, body language, and the study of communication systems [20].

It was observed that when people do things under stress or tension, their reactions are always automatic, ie their performance is controlled on a subconscious level. These subconscious reactions may be positive and useful, but may also be negative and unhelpful. NLP is designed to teach how to communicate more successfully and create the right climate for success. It increases the sensitivity towards the body language and signals that others are sending in order to be able to interpret them correctly and adjust a communication pattern to be accurately understood. Moreover, it helps to handle negative experiences, eliminate stress, phobias and depression, thus being able to gain full consciousness of one's own behaviour, reactions and performance.

Communication is a multi-channel process and it can only be truly efficient if all the parties involved experience no communication barriers, ie they can express themselves clearly, present themselves appropriately and listen effectively. As stressed by Kaye, it is also very important to be an effective listener especially in team-based projects and in all oral communication [21].

Cerri recommends that engineers learn to understand the *human process of perception, communication and cognition* and suggests a *7-Step Effective Communication Process* as follows:

1. Understand which of the five senses (or representational system) the listener is operating and match it;
2. Build an unconscious rapport with the listener by reducing his/her filtering utilising such techniques as mirroring, matching, pacing, as well as leading verbal and non-verbal clues;
3. Uncover the listener's paradigms of reality by quick and elegant questioning;
4. Send the message, ie present ideas and issues that the listener may not agree with, but if the rapport was built successfully, then the listener will be able to hear the message in an unbiased way;
5. Check to determine if the message was received in the intended way;
6. Go back to steps 1-3 if the message was received distortedly;
7. Send the next message [3].

He also claims that *excellent communication is a process and an ability that can be learned* [3].

CONCLUSIONS

Numerous researchers report the following:

- *... many, if not most, engineers have trouble writing and speaking clearly* [4];
- Billions of dollars are lost in terms of corporate productivity and profitability yearly when engineers have problems with written communication [22];
- Common barriers to communication for engineers include the lack of knowledge or experience, poorly defined ideas, messy written communications, one-sided or inappropriate communication, failure to bridge differences in values, attitudes or perceptions with the audience, and poor listening skills [23].

Williams sees the possibility of the development of an engineering portfolio based on the following five principles:

1. *Defining* engineering communication;
2. *Identifying* appropriate skills and mapping them in the curriculum;
3. *Correlating* portfolio learning objectives to course and programme objectives;
4. *Facilitating* opportunities for students to reflect on their learning;
5. *Assessing* student learning so that students, faculty and programmes can benefit and improve [24].

It is difficult not to agree that good communication skills must be an integral part of modern engineering curricula. The authors believe that engineering curricula have to be re-evaluated to meet the demands and be responsive to the needs of industry and science. Hence, there should be an ongoing incorporation of communication skills across the engineering curriculum so that it will be possible not only to continuously develop communication competence but also communication performance.

It is assumed that a more efficient enhancement of communication skills is achieved not by offering separate communication courses or by integrating them into engineering courses but realising them on the basis of teaching/learning ESP. On the one hand, it is a more natural way to develop communication skills and interpersonal communication abilities via language teaching; on the other hand, ESP gives an opportunity to involve appropriate engineering content, model and exercise tasks that would be relevant to real engineering activities.

The primary objective is for students to be skilful enough to implement appropriate communication patterns to meet engineering communication challenges. It should also be kept under control what approaches, teaching methods and techniques are implemented to make the developed curriculum work. Implementing information and communication technologies may greatly help to prepare competent and confident communicators with good communication tools at their disposal.

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BIOGRAPHIES

Mrs Elena A. Danilova was born in Tomsk, Russia, where she completed her education in 1998 by receiving a diploma with Honours from Tomsk State Pedagogical University (TSPU) in the field of linguistics and teaching foreign languages (English and German). In the same year, she obtained a lecturer position at Tomsk State University in the Department of Roman-Germanic Philology with the responsibility to teach English as a foreign language. Between 2000 and 2006, she was a lecturer in English for Specific Purposes (ESP) at Tomsk Polytechnic University in the Institute of Foreign Languages, Department of Linguistics and Cross-cultural Communication, and, concurrently, in the Institute for International Education.

In 2002, she obtained her Cambridge ESOL Certificate in Advanced English (CAE), and in 2004, she became an alumna of the professional development programme offered by the USA Embassy in Moscow through which she completed the online course called *Integrating the Internet into the Classroom*. She has also enriched her teaching experience by tutoring international students for Preliminary English Test (PET), Key English Test (KET) and First Certificate in English (FCE) at the Solihull College, West Midlands, UK (2002), and the Harvest English Institute, Newark, USA (2003).

Mrs Danilova finds her teaching profession very noble and responsible. In 2004, in order to make her professional experience more efficient, she began a research project on using Information Technologies (IT) for ESP teaching. The field of her scientific endeavour includes the following areas: developing new methods for teaching English to engineers using IT; teaching English online and/or using Internet resources and technologies; implementing a process-oriented approach, and motivating and rewarding learning styles; researching and learning how to design courses on the basis of learning management systems like *WebCT*, *Learning Space*, etc; developing self-study activities for engineering students; and enhancing communication skills.

Presently based at the UNESCO International Centre for Engineering Education (UICEE) in the Faculty of Engineering at Monash University, Melbourne, Australia, Mrs Danilova is enrolled as a full-time postgraduate student (PhD candidate) in the Faculty of Arts via the Monash Asia Institute (MAI), with the UICEE Director acting as the Main Supervisor. Her current studies focus on research into the curriculum development for English and communication studies in engineering and technology courses, with particular emphasis on ESP.

In 2006, Mrs Danilova received the *UICEE's Women in Engineering Education Scholarship*, enabling her to commence her postgraduate studies at Monash University, and in 2007, received two highly competitive scholarships: the *Monash International Postgraduate Research Scholarship* and the *Monash Graduate Scholarship*.

Her research has, so far, been recognised by the UICEE Best Paper Diamond (First Place) Award for a paper presented at the *9th Baltic Region Seminar on Engineering Education* (Gdynia, Poland, 2005) and the UICEE Best Paper Silver (Fourth Place) Award at the *11th Baltic Region Seminar on Engineering Education* (Tallinn, Estonia, 2007).

Zenon Jan Pudlowski graduated Master of Electrical Engineering from the Academy of Mining and Metallurgy (Kraków, Poland), and Doctor of Philosophy from Jagiellonian University (Kraków), in 1968 and 1979, respectively.

From 1969 to 1976, he was a lecturer in the Institute of Technology within the University of Pedagogy (Kraków). Between 1976 and 1979, he was a researcher at the Institute of Vocational Education (Warsaw) and from 1979 to 1981 was an Adjunct Professor at the Institute of Pedogogy within Jagiellonian University. From 1981 to 1993, he was with the Department of Electrical Engineering at The University of Sydney where, in recent years, he was a Senior Lecturer.

He is presently Professor and Director of the UNESCO International Centre for Engineering Education (UICEE) in the Faculty of Engineering at Monash University, Clayton, Melbourne, Australia. He was Associate Dean (Engineering Education) of the Faculty of Engineering between 1994 and 1998.

In 1992, he was instrumental in establishing the International Faculty of Engineering at the Technical University of Lodz, Poland, of which he was the Foundation Dean (1992-1995) and Professor (in absentia) (1992-1999). He was also appointed Honorary Dean of the English Engineering Faculty at the Donetsk National Technical University in the Ukraine in 1995.

His research interests include circuit analysis, electrical machines and apparatus, implementation of computer technology in electrical engineering, software engineering, methodology of engineering education and industrial training, educational psychology and measurement, as well as human aspects of communication in engineering. His achievements to date have been published in books and manuals and in over 350 scientific papers, in refereed journals and conference proceedings.

Professor Pudlowski is a Fellow of the Institution of Engineers, Australia, and of the World Innovation Foundation (WIF), UK. He is a member of the editorial advisory board of the *International Journal of Engineering Education*. He is the founder of the Australasian Association for Engineering Education (AAEE) and the *Australasian Journal of Engineering Education* (AJEE), and was the 1st Vice-President and Executive Director of the AAEE and the Editor-in-Chief of the AJEE since its inception in 1989 until 1997. Currently, he is the Editor-in-Chief of the *Global Journal of Engineering Education* (GJEE) and the *World Transactions on Engineering and Technology Education* (WTE&TE). He was on the editorial boards of the *International Journal of Electrical Engineering Education* (1993-2005) and the *European Journal of Engineering Education* (1993-2005). Prof. Pudlowski was the Foundation Secretary of the International Liaison Group for Engineering Education (ILG-EE) (1989-2006) and is currently its Chairman.

Professor Pudlowski was a member of the UNESCO International Committee on Engineering Education (ICEE) (1992-2000). He has chaired and organised numerous international conferences and meetings. He was the Academic Convener of the *2nd World Conference on Engineering Education*, the General Chairman of the *East-West Congresses on Engineering Education*. He was also General Chairman of the *UNESCO 1995 International Congress of Engineering Deans and Industry Leaders*, and General Chairman of the *Global Congress on Engineering Education*, to name a few.

He received the inaugural AAEE Medal for Distinguished Contributions to Engineering Education (Australasia) in 1991 and was awarded the Order of the Egyptian Syndicate of Engineers for Contributions to the Development of Engineering Education on both National and International Levels in 1994.

In June 1996, Prof. Pudlowski received an honorary doctorate from the Donetsk National Technical University in the Ukraine in recognition of his contributions to international engineering education, and in July 1998, he was awarded an honorary Doctorate of Technology from Glasgow Caledonian University, Glasgow, Scotland, UK. He was elected a member of the Ukrainian Academy of Engineering Sciences in 1997. In 2002, he was awarded the title of an Honorary Professor of Tomsk Polytechnic University, Tomsk, Russia, and was an External Professor at Aalborg University, Aalborg, Denmark (2002-2007). He is listed in 14 *Who's Who* encyclopaedias, including the Marquis *Who's Who in the World*. He has been recently appointed to the Register for External Reviewers of the Oman Accreditation Council (OAC).

Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

The Volunteer Learning Support Scheme for International Students (VLSSIS)*

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Students who study in a foreign country face challenges not necessarily faced by local students. It could be argued that although some of these challenges are not the responsibility of the local educational institution, they can have an impact on students' academic success and their enjoyment of the new environment. It is desirable for educational institutions to provide not only learning support to students, particularly international students, but also an adequate level of personal support. In this article, the authors outline the context, management and operation of the Volunteer Learning Support Scheme for International Students (VLSSIS) within the Centre for Learning and Professional Development (CLPD) at the University of Adelaide in Adelaide, Australia, and discuss some of the learning and personal issues facing students studying and then working in a foreign country. Volunteers within VLSSIS have found that while there is great diversity among international students, certain common themes and issues relate to their past learning and cultural experiences. The volunteers' work aims to maximise students' success by offering them an informal learning situation in which they become more confident in all aspects of local language and culture, both within the University and beyond.

INTRODUCTION

Education is now an international business (in South Australia, international education is the fourth largest export exceeding A$500 million per annum). The traditional concept of *bricks and mortar* institutions providing for the learning needs of local students has been replaced by an environment of global competition for students and for the provision of educational services. Students who study in a foreign country face challenges not necessarily faced by local students. It could be argued that some of these challenges are not the responsibility of the local educational institution: nevertheless they can have an impact on students' academic success and on enjoyment of their new environment. As such, it is necessary for educational institutions to provide not only learning support to students and, especially international students, but also an adequate level of personal and cultural support. All students have expectations and these expectations need to be seriously considered by host institutions. However, international students may have some expectations that cannot readily be satisfied without cultural and operational change in the university.

Within the University of Adelaide in Adelaide, Australia, one development that has contributed significantly to addressing the repeatedly stated concerns of international students about their communication difficulties, is a programme provided by volunteers from the local community. This programme is run and administered by the Centre for Learning and Professional Development (CLPD), which also offers learning and formal academic language support to all students. The volunteer programme specifically addresses international students' challenges in oral communication and cultural understanding. As one PhD

*A revised and expanded version of a paper presented at the 10^{th} *UICEE Annual Conference on Engineering Education*, held in Bangkok, Thailand, from 19 to 23 March 2007. This paper was awarded the UICEE Best Paper Silver (Fourth Grade) Award by popular vote of Conference participants for the most significant contribution to the field of engineering education.

student from Thailand put it, *I am a research student and do not have much chance communicating with English native speakers. Also, most of my friends are Asian students. It is hard to pick up our mistakes as long as we are understood. This limits my opportunities of improving my communication skills*. The main aims of the volunteer programme are to increase students' confidence in all areas of English communication competence and to extend their level of cultural awareness and understanding of Australian mores and attitudes. It is believed that through regular contact with a sympathetic and sensitive local person students are more able to make the most of their time in Australia both in their studies and in the wider community.

In this article, the authors outline the context, management and operation of the Volunteer Learning Support Scheme for International Students (VLSSIS) within the CLPD at the University of Adelaide. It was deemed appropriate to locate this programme within the CLPD as it is often during more formal academic programmes run by the CLPD that students voice their concerns about their informal language skills. In situations within their study area – meetings with staff, tutorial participation, telephone conversations and oral presentations, as well as chatting with local students – they find themselves lacking the ability to make themselves understood and to understand the local idiom. The programme aims to redress some of these difficulties through regular practice with a volunteer. There is an emphasis on students' meetings with volunteers being relaxed and enjoyable, aiming at minimising the pressure which students too often feel in their academic courses.

The programme operates separately from students' coursework or research. Students' partnerships with their volunteers thus offer an opportunity to explore issues confidentially. Students may request a CLPD volunteer at any stage of their studies. While academic staff may at times recommend students seek a volunteer, it is imperative that students themselves freely commit to this involvement. Volunteers within the VLSSIS assist students with general English language development and with understanding the context of the many challenges they face within the University and beyond. Accommodation difficulties, social situations and the workplace environment are examples of areas that students find daunting. Volunteers may also work with students to develop strategies and access resources to address these issues.

VOLUNTEERING IN SOUTH AUSTRALIA

Australia has a well-established tradition of volunteering. Volunteers provide crucial support for community and emergency services, as well as for welfare, cultural and educational organisations. Many of the more remote communities in Australia would not be viable but for volunteers providing local services such as ambulance and fire-fighting. In South Australia, the level of volunteering in the community is increasing. Surveys by the Australian Bureau of Statistics in 2000 for the Office for Volunteers showed that some 38% of the population were involved in formal volunteering activities (ie that done for an incorporated organisation, excluding voluntary work for one's family or neighbours; an incorporated organisation is one recognised in law, such as a company, a statutory authority, eg a university, or a not-for-profit organisation, eg a sporting body) and that this figure had increased in 2006 to 51% overall and 63% in rural areas. The increase in volunteering can be partly explained by the country's demographic profile, in particular the increasing retirement of those born between the years 1945 and 1950. These people are often well qualified and experienced, financially secure, physically active and in good health and want to contribute to the community in a different way. For others, volunteering can enhance personal and work skills and is increasingly seen as a pathway to employment.

Volunteering brings benefit to both the community and the individual volunteer. Mayer reviewed a number of research reports from around the world and concluded that high levels of volunteering have an inverse relationship to crime and a positive relationship to community health, education and economic growth [1]. Ironmonger concluded that South Australian volunteers donated an additional 11.5% of gross state product in 2000 compared to 7.8% in 1992 [2].

Legal Implications

Volunteering has been encouraged by government in South Australia through legislation and the provision of infrastructure. A traditional concern of many people has been the possible liability in common law (in Australia, common law is based on what is *fair and reasonable* and is built on legal precedence, compared to legislative law based on an act of parliament) should they cause injury to a person, even if such injury was not intended. For example, a volunteer assisting students in a university may give a student incorrect or poor advice, and hence cause injury resulting in the student seeking redress in common law. The South Australian Volunteers Protection Act 2001, subject to certain conditions, provides:

> *... protection to individual volunteers from personal liability for loss, injury or damage caused as a result of an act or omission on their part while undertaking volunteering*

duties on behalf of an incorporated organisation [3].

The incorporated organisation is not protected from liability and needs to embed such liability into its risk management processes by providing guidelines and training for volunteers and through relevant insurance.

Management of Volunteers

While there are parallels between the management of paid employees and volunteers, there are also important differences. Paid employees are bound to the employing organisation through the wish to reliably earn an income and this may constrain their actions. A volunteer is not similarly constrained, but is quite free to disassociate from the organisation. Paid employees may be required or even directed to undertake some task consistent with their employment. Volunteers may be asked to undertake some task consistent with their accepted role, but it is their free decision as to whether they comply. Management respects individuals' right to choose their level of commitment. Promotion is usually irrelevant for volunteers although recognition and personal satisfaction are likely to be crucial. Work conditions must also be tailored to suit individuals. Techniques for managing an effective group of volunteers are different from those appropriate for paid employees, and require a very flexible and sensitive style of management.

VOLUNTEERING AT THE UNIVERSITY OF ADELAIDE

The state of South Australia, with a population of about 1.6 million and a land area nearly three times that of Japan, has three universities. Less than 40 years after the founding of the colony of South Australia, the University of Adelaide was established in central Adelaide in 1874. The University is a medium-sized institution with about 15,000 EFT students including some 3,000 EFT on-shore international students, mostly from Asian countries including from China (37%), Malaysia (20%) and Singapore (14%) in 2005. It has a strong research history and, over the years, its staff and students have won a number of Nobel prizes.

The University of Adelaide has about 1,000 volunteers (about the same number as academic staff) involved in a wide range of activities including tour guides, archivists, theatre enthusiasts and radio station operators. While the University has a corporate approach to volunteers, including an accepted code of behaviour and occasions to recognise the contribution of volunteers, most groups of volunteers in conjunction with paid staff are self-organising. This allows the groups of volunteers to function more as a family or informal partnership than a large organisational unit requiring more formal structures with greater overheads. Many volunteers have had a lifetime of working in large corporate organisations, and may now want to be involved in a simpler and more personal structure where they have a measure of autonomy and their contribution is very much *hands-on*. Younger volunteers also enjoy the opportunity to have their opinions valued and to take responsibility in a new area of expertise. Flexibility is a core principle for the management of the VLSSIS, with volunteers being encouraged to make all arrangements with their students to suit their mutual convenience.

Approximately 60 volunteers are associated with the CLPD, particularly with the VLSSIS. The CLPD provides formal professional development for academic and general staff, and learning support for both local and international students. The learning support is given through written guidelines, online services, individual tuition and group workshops. This combination of activities at the CLPD allows the learning issues of students, including those identified by the VLSSIS, to reflect directly into the professional development of staff. Advice and personal support to students is provided not by the CLPD, but by the International Student Centre, a separate operational unit within the University that operates in close cooperation with the CLPD.

VLSSIS volunteers come from a wide range of backgrounds with the fundamental requirement being a willingness to spend time with an international student to facilitate his/her transition into living and studying in Australia. Included in the volunteer group are a number of retired academics, business and professional people, workers and students from various areas in the University and others from the community, who fit their volunteer work in with their ongoing work commitments. Young and old are all welcome. Due to minimal funding, recruiting has also been minimal. The main source of new recruits is through *word of mouth* by other volunteers. A testament to the level of satisfaction of the volunteers is that there are a number of the original recruits from 1995 still working with students. Very few give up their volunteer work unless health or change of other circumstances demands it.

INTERNATIONAL STUDENTS

Like most Australian universities, the University of Adelaide was originally developed to extend the education and training of local students. For some 100 years, there was little student movement between universities in various states of Australia, and what there was tended to be for programmes not available in a particular state; veterinary science, for example, has never been offered in South Australia. With changes in government policy for universities encouraging greater choice, Australian students started to seek enrolment interstate, but this did not significantly change the established student profile of the universities.

About 10 years ago, and in response to reducing government funding, Australian universities started to market themselves to international students and have been successful in doing so. International students now make up a significant proportion of students at some universities, although universities tend to retain the characteristics developed to satisfy the needs of local students. Coming from a different learning culture and experience in their home countries, international students often do not share local students' expectations of university life. They may expect a higher integration of living, study and work.

Many international students have difficulties with the independent learning style required in Australia. Almost without exception, international students are intellectually capable, highly motivated and hard working, but in adapting to their new environment, they face a number of challenges. Despite their general success, some students are at risk due to their limited English language skills, lack of independent learning skills, and difficulty in understanding the Australian academic context and Western philosophy. Some international students have to pay their own fees and costs, and are under constant financial pressure. A proportion of graduating international students decide to work in Australia on the basis of either a working visa or permanent residency, and this decision creates a new range of issues that have to be addressed. Sometimes, unfortunately, their efforts are not successful.

In summary, many of the issues faced by international students are not the direct concern of a university, but may nevertheless seriously impact on students' learning, their enjoyment of time in Australia and their future. It is quite evident that, as well as dealing with the daunting task of undertaking studies in a foreign country, many students suffer from isolation, limited understanding of Australian university culture and difficulties in dealing with the wider community.

VOLUNTEER LEARNING SUPPORT SCHEME FOR INTERNATIONAL STUDENTS (VLSSIS)

Development and Management

The VLSSIS was developed in 1995 by the co-author and was partly based on earlier experiences with English language services for adult migrants. International students share many of the same *culture shock*, language and settling-in difficulties. As the Australian Government-funded volunteer scheme for newly arrived migrants had proved so successful in helping the settlement process, it was decided to tailor a similar programme to the University's international students. Despite their relatively competent English, students repeatedly asked for assistance in communicating with local people.

With the help of a small equity grant, the programme was established with 25 volunteers working with some 40 students. Over the years, many hundreds of students have benefited. In 2006, the number of volunteers had grown to 60. People are recruited from the general community and given some briefing on their role and responsibilities. At all times, it is emphasised that the programme is intended to be flexible, concentrate on informal communication and attempt to meet the expressed needs of the students. Shared activities with volunteers is intended to help mitigate the high level of stress that many students experience in undertaking their formal studies. The qualities required of volunteers are an interest in people from other cultures, some understanding of the local tertiary education system, and a willingness to meet regularly with an international student and form an ongoing relationship.

The VLSSIS receives very low funding of about A$5,000 per annum, which is adequate to coordinate the group of about 60 volunteers, many of whom are mature and experienced. The group is managed using relatively informal procedures relying very much on goodwill and an extremely high level of commitment from participants – both students and volunteers. Each partnership is encouraged to operate autonomously and may continue as long as the student requires. One student from Japan reported,

> *I have known* [my volunteer] *for six years. When we started meeting, my English was very poor. However, she has been really patient with me and I am sure that my English (written and spoken) would never have improved without her. I cannot express my gratitude to her enough. What we did in our sessions, whether conversations or discussion of my work, led me to this achievement of my PhD.*

Unfortunately, not all international students who want to be involved with the VLSSIS can be accommodated, and there is a demonstrated need to expand beyond the present group of volunteers. Given the University's alumni and community support, it is likely that the number of volunteers could be increased without too much difficulty. Obviously, additional funding would be required and, more importantly, a more formal management approach would become necessary, which would increase per capita overheads. Increased formality may result in the loss of some volunteers, most of whom want to maximise their interaction with the international students. They may not support a more formal approach by management.

Intending volunteers apply to the CLPD for membership and are required to thoroughly understand their role and responsibilities, including the code of conduct. A commitment by volunteers of at least 1½ hours per fortnight is required. A teaching or professional background is not required but flexibility, cultural understanding and sensitivity are important. Some initial training is provided to volunteers, and regular group meetings provide an opportunity to share information and experiences. Volunteers and the coordinating lecturer are in regular contact and the coordinating lecturer periodically surveys international students seeking their feedback. Difficulties between a volunteer and a student can arise, mostly through language or cultural misunderstanding. These issues are usually minor and easily addressed through mutual goodwill. At all times, the coordinator is available to assist or manage any questions or issues between students and volunteers.

Conversation Class

VLSSIS volunteers are involved with international students in two main ways. Firstly, some volunteers and CLPD academic staff meet with international students once a week at a conversation class. Students may attend regularly or when their other commitments allow them some time. As with all the activities involving CLPD volunteers, it is considered most important that students can relax and benefit from the informal learning atmosphere offered by the volunteers.

The conversation group usually focuses on a particular topic that relates to most students – ideally, these topics are suggested by students themselves. Talk is often oriented to cultural and social practices. Discussion may include food, public holidays and social events, as well as situations that may cause dismay like group-work participation, accommodation problems, difficulties with neighbours and job-seeking. As people get to know each other, trust grows and communication is enhanced. A student from China noted, *after meeting for some time I find I can speak confidentially which makes me feel more confident and free to speak to others*.

Each student is encouraged to talk about their own experiences, and to gain some appreciation of the cultural and social practices of other countries. To a large degree, the learning opportunity is a confidence-building exercise. Students often believe that their problems arise from a lack of language skills, but a range of other issues may, in fact, be more important and suggestions can be made as to how these issues can be addressed. Volunteers can provide a valuable link between international students and the general community, and students can ask a wide range of questions in a non-threatening environment, for example how to decline an offer politely, how to cook a particular dish or how a particular incident is interpreted by Australians and those from other cultures.

There is a lot of *fun* in the discussions, especially as students start to become aware of Australian humour and idiom. Students participate in these meetings with considerable enthusiasm and constantly comment on their value in helping them to understand students from other countries, including those countries with different political or economic viewpoints. As well, students regularly comment on the great benefit of having *Aussie* volunteers to give them opportunities to listen to and appreciate the local idiom and points of view. One Malaysian student commented: *Australians like to keep their words* short and sweet. *Their speaking is hugely different from what we learnt in our home countries. I can't learn this from formal lessons.* Students have often said, *I can now participate better in tutorials and group-work activities*.

Volunteers with Individual Students

The second way that volunteers support international students is by meeting one or more of them on an individual basis, usually for one hour a week. International students apply to have an individual volunteer and the coordinating lecturer attempts to match the profile of the student with that of a volunteer. In general, international students are expected to first attend the conversation class for several weeks so that the coordinating lecturer can assess their language skills and needs, and the student has an opportunity to meet and understand the volunteers' role. While the primary function of the volunteer and individual student in meeting is to practise general informal English conversation, there are occasions when an international student requests a volunteer who is familiar with their particular field of study, perhaps *History of Western Art* or *Astrophysics*. The coordinator attempts to satisfy such requests and often a suitable, possibly new, volunteer can be found. In other cases, a volunteer may be learning a foreign language and can be linked with a student who is a native speaker of that language. This creates a very rewarding situation for both.

At times, a volunteer will be matched with a student sharing the same discipline. The main concern of the coordinator is to facilitate a harmonious working partnership that fosters ease of communication. Feedback from students has repeatedly stressed the value of the friendships they form with their volunteers. *We are not just student and volunteer*, a student from China said, *we regard each other as good friends*. Another said, *the most useful outcome for me is to make a good friend in a foreign country*.

The first few meetings between a volunteer and student are critical in building a successful relationship. Mutual respect is the key to the interaction. The meetings between the volunteer and student are voluntary, and both parties must understand that they are free to terminate the arrangement. Once a comfortable relationship has been established, it then usually continues for the academic year before being reviewed. The overwhelming majority of students wish to continue meeting with their respective volunteer the following year.

There is considerable diversity in the profiles of VLSSIS volunteers working with individual international students. Volunteers and students quickly develop their particular arrangements; some read together, some talk about cultural and social matters, while others go shopping or share other activities. Meeting places are also diverse – some meet on campus, in the city, at home as they get to know each other, or in broader group activities like bushwalking. Volunteers encourage students to take the initiative within their interaction and this in itself is a learning experience for those students from cultures where it would be usual to defer to the older or more experienced person. It is not the role of the volunteer to directly assist students with their studies, although most students want to talk about new words that they do not understand or issues and ideas associated with their studies. A volunteer may be well informed in the area that the student is studying and there is no reason why the student should not access that knowledge as from any other information source.

It is recognised that there is the possibility of conflict between volunteers working with international students and academic staff, especially supervisors of research students. The experience of the co-author has been quite the opposite and he has always been warmly greeted by academic staff, who acknowledge the valuable complementary role of volunteers.

There are a number of support mechanisms available within the University for international students and volunteers may direct students to these services as needed. Many international students find it difficult to accept that there are staff employed by the University to advocate on their behalf and students may be suspicious of such services. Most students readily accept their volunteer, suggesting that they should talk with a specific person about an issue or accompanying them to meetings in an independent support role.

Having agreed to work with a particular student introduced by the coordinator, the co-author has found it useful to establish some initial communication with the student through e-mail if they have not already met at a conversation class. International students often find meeting and face-to-face conversation with a stranger, particularly one who is older and more experienced, quite difficult at first. An e-mail exchange of some personal information and a photo helps them to feel more comfortable.

Volunteers develop their own set of objectives for their relationship with an individual student. For the co-author, these are that the student is academically successful, enjoys their time in Australia, has cultural experiences not otherwise possible, develops an international network and obtains professional employment if they decide to stay in Australia. Likewise the co-author has set rules for meetings with international students. They agree to meet for two weeks and then in order to decide whether to continue with their arrangement; they will wait for each other for up to 15 minutes after the agreed meeting time in case either has been delayed for some reason; when they meet, the student can talk or ask about anything they like. The student is also free to e-mail the co-author and may do this several times a week, and the student is also able to phone at any time if there is an urgent need. As stated, each volunteer and student create their own parameters.

Feedback

The CLPD coordinating lecturer regularly surveys those international students participating in the VLSSIS, and holds regular meetings and maintains frequent contact with volunteers. The feedback from international students is overwhelmingly positive: *thanks for giving me this precious chance* is a repeated refrain. The comments include common themes like appreciating the opportunity to have contact with an encouraging local person, learning new words and expressions, and understanding Australian culture. As a result of their positive experiences with the VLSSIS, some become volunteers themselves, either in the CLPD programme or as *peer greeters*, who meet and welcome new international students. Some also express the wish to set up something similar in their home countries. Volunteers are frequently invited to their students' graduations and other special events, and many international graduates maintain contact with their volunteer for years after they return to their home country. Students clearly enjoy being in a reciprocal partnership where they are offering something valuable too.

Volunteers comment on the opportunity to learn about other countries and cultures, and to be intellectually stimulated. There is also the satisfaction of sharing with international students as they grow academically and personally. Volunteers also stress the value of being helped to view their own society through the eyes of an outsider. Volunteers in the programme can use their experience as a valuable asset in their CVs for new jobs. Several student volunteers now work as English teachers overseas.

INTERNATIONAL STUDENT ISSUES

Living and Culture

Many international students have not previously been away from their families, let alone overseas before. To come to a foreign country with a foreign language and culture, and to survive without the support of their extended families is certainly a new and challenging experience. International students come with expectations based on their previous social context and learning, and these unfortunately may not be applicable or relevant in Australia. Likewise, they are often amused that Australians have concerns or interests that seem absurd; an Australian's idea of heavy vehicle traffic may be quite different from theirs.

A large number of international students adapt to the new unfamiliar living environment within a few weeks in spite of adverse incidents and setbacks, such as cars driving in the opposite direction or not finding their favourite foods. For others, it is an exasperating experience. They lose confidence and do not know what to do, and unless there is some intervention, for example by a VLSSIS volunteer, they may well face failure. Family and social expectations of success add to their anxiety. Some undergraduate students are personally immature and the VLSSIS volunteer may almost become a de facto parent. One student from Vietnam said about her volunteer, *she gives me a good feeling as when I am with my aunty*. It is made clear to volunteers though that they choose exactly the level of involvement that suits them. At all times there are resources available to both student and volunteer to smooth the way through difficulties.

Many international students tend to live with others from their own country, which is quite understandable. However, such arrangements can be counterproductive, restricting their language development and broader experiences. Regular contact with a volunteer helps alleviate these limitations and offers friendship, as well as language and cultural extensions. After spending time with her volunteer, one student from China said *I now know more about the people's life-style, what they usually do, where they usually go and so on. I feel myself closer to the country, to the city and to the people here through our time together*. And, *I receive many suggestions about my study and life-style. It is very helpful for me during* [any] *critical moments*, reported a student from Bangladesh.

As would be expected, international students often cannot assess risk in their new environment and may place themselves in considerable danger. Sometimes, their new found freedom results in inappropriate behaviour like gambling, or they do not realise that the car that they bought for A$500 is not roadworthy under local law. These pitfalls and many others are minimised by sharing everyday conversation with volunteers, who can often offer a different perspective on a situation. In serious cases, University staff personnel may be called in to assist.

English Language Proficiency

International students are required to have a prescribed level of English language proficiency before enrolment and some are required to undertake additional English courses as a condition of enrolment. Research students undertake a preliminary programme that further enhances their English skills. Even though students from some countries, such as Malaysia and Singapore, usually have very competent English language skills, there are still issues related to *Australian English* with its particular accent, idiom and style.

It often takes about 12 to 18 months for a student to become confident in conversational English. They usually make rapid progress once they start to think in English rather than mentally translating into their native language. Discussing the translation issue with their volunteer usually reduces their anxiety about not being able to quickly perfect conversation skills. Spoken English is not consistent between English speaking countries, which is confusing for students who believe that they have been previously taught the *correct* English, perhaps by a British or American teacher. The Australian idiom is particularly difficult for international students. International students are often overly concerned about their pronunciation, and sometimes assistance is necessary to help them with certain sounds and words, for example those words beginning with *w*, *z* or *y*. In all these areas of language acquisition, the ongoing relationship with a volunteer can help to increase greatly the student's confidence and competence in day-to-day exchanges. A

Japanese student commented: *When I could not find a correct word I used to give up. Now I try to find another way. The change is because my volunteer always encourages me. She always has a sense of humour*.

In students' writing, their problems may be more about structure and argument than the actual English words. Some students base their writing on the simplistic style of newspapers rather than referring to learned journals and texts. Problems include difficulties with grammar, critical analysis, plagiarism and referencing. Learning support staff at the CLPD provide assistance on these matters. At times, students try to write their assignments in their native language and then translate into English. This is quite unsatisfactory. In spite of their convenience, translating dictionaries are not adequate and a reputable English dictionary is essential. Volunteers can assist by encouraging students to refer to their dictionaries as they confront new words in their conversations. If the volunteer is willing, students share their written draft copies during their time together, but the emphasis is always to be on spoken communication. Most students develop sufficient written language skills during a higher degree to present an acceptable thesis although perhaps with some editorial assistance. This is not the responsibility of VLSSIS volunteers, although they may choose to be involved to some degree. Students are reminded that their volunteers are not intended to be editors.

Learning Skills

The main difficulty that students have to overcome is that the current learning style in Australia is very independent, and students are expected to research subject matter and to develop their own arguments; lecturers expect students to be independent thinkers. Some international students would not usually challenge a lecturer over an issue – even if the lecturer has made an error. In their previous academic experience, many international students have been taught that lecturers should be always correct and always know the answer. Likewise, there is a tendency for students to think that they have to know everything in the course and do each assignment or presentation perfectly. This puts the student under great pressure, causing them to study for long hours to the detriment of their health and without improvement in their academic results. Initially, students are often disturbed when lectures do not follow the sequence of chapters in a textbook, when the solution to some problem is not obvious or when there is missing or conflicting data. Likewise, initial examination results are often poor because students are not familiar with examination techniques in Australia and under the pressure of an examination, find new techniques difficult to implement. Students in the sciences and engineering are at an advantage compared to those in the humanities. The basic language and tenets of science, mathematics and engineering are common throughout the world, but Western philosophy underlying much of the humanities presents significant challenges to Asian students. In addition, language in the humanities is much more complex than in the sciences, and to effectively read and fully understand sophisticated arguments are formidable tasks.

Another common learning difficulty for international students is effective participation in tutorial work. This is evident especially where tutorial group participants are not yet sensitive to the limited language skills of some group members. In some fields, tutors are often postgraduate students towards the end of their candidature and may have English language limitations of their own, as well as limited skills in managing group dynamics. Volunteers can encourage international students to develop a few simple techniques based on group responsibility to enable their full participation and benefit other group members. These characteristics are also facilitated at the weekly conversation group sessions with volunteers. Students can practise their language and presentation skills as well as actively engage with other students.

Most students, local and international, experience considerable anxiety in preparing a seminar presentation and despite good guidelines regarding the *mechanics*, they do not appreciate the communication process. International students have the additional worry that they might mispronounce a word and find it difficult to accept the advice that should this occur, and it will, just to continue as if nothing has happened.

The majority of international students graduate despite all the issues and challenges of living and studying in a foreign environment. Intelligence and persistence wins through. VLSSIS volunteers consider it a privilege to be part of their students' success.

Mixing and Conversation

A university provides an opportunity for students of different backgrounds to mix and learn from each other. However, for a number of reasons, international and local students often do not mix to any extent, and do not utilise the opportunity to broaden their perspectives and develop networks.

Many international students share accommodation with others from their own country and, while this provides friendship and security, it does not encourage English language development or skills in social interaction in an unfamiliar situation. It takes some practice by both international and local students to develop successful conversation skills, and to be comfortable in saying more than *hello* to a person they do not know. However, in these days of global business, this is a critical skill in networking. Again, practising conversation *openers* with a sympathetic volunteer can benefit international students.

In some university programmes, international students are in a minority and may be excluded from already established groups of local students, who may not be aware of their behaviour. Sometimes, too, local students feel as shy as the international newcomers. In other programmes, such as coursework Masters' programmes, there may be many more international students than local students and again this can deter social mixing. It is important that academic staff take every opportunity to encourage the mixing of international and local students by managing interaction in tutorial and laboratory work, and in research groups. In the future, it may be possible for volunteers to be included in some of these learning situations to facilitate better working exchanges.

Employment

Many international students need to work part-time to support living and studying in Australia. After graduating, a number decide to stay in Australia for several years to gain work experience whereas others decide to make Australia their home through seeking permanent residency.

Many graduates are unprepared for the market-economy driven Australian workplace. Gaining an understanding of the nature of the workplace, the need for networks, the need for initiative, flexibility and adaptability, the need to package and market oneself, the development of job applications, preparing for, and performing well in, an interview, negotiating workplace agreements, work-performance reviews, and becoming familiar with workplace laws and regulations are all additional challenges. International graduates need support and their former VLSSIS volunteer is often the person they turn to. Not all graduates are successful in gaining employment in Australia; some become underemployed, some retrain into an entirely different field while some others return to their native country.

Adapting on Return Home

While some international graduates remain in Australia and eventually become Australian citizens, most return to their home country and again need to adapt. Even if they have been in Australia for only one or two years, they will find that they, their families and their society have all changed. When they return to their homelands, many feel alienated, if only for a short period, just as they felt when they first came to Australia. They may find that elderly relatives have died, siblings have left home and their former friends have left the area or are now married with children. In addition, the social and economic conditions of their home country may have changed, especially in those countries in rapid development.

Most international graduates report that they have lost fluency in their native language while in Australia and tend to mix a few English words into their initial conversations. Their thinking has become Australian and while this may continue for only a few weeks or months, it can generate family disappointment. Some report that they have lost employment opportunities and promotion while in Australia, and experience initial difficulties in finding suitable employment. Unfortunately, a few feel that they cannot reintegrate, return to Australia or move to a third country to begin a new life.

CONCLUSIONS

The VLSSIS has been successfully operating for 12 years at low cost. In that time, the VLSSIS has been able to assist many hundreds of international students by supporting their learning through language development, and sharing cultural and social information. Feedback from students clearly shows their appreciation of the personal support provided by volunteers. A 2006 Chinese student commented that his volunteer helped him *to balance my study and my life. I would appreciate if you give every international student this cherished chance*. Some students have graduated where they might otherwise have failed, while others have achieved high distinction rather than more limited success. Feedback from volunteers has confirmed that they enjoy their involvement, which adds to their own cultural experiences. Along with other volunteers, the VLSSIS forms a link between the University and the community to the mutual benefit of both. The relationship between an international graduate and their VLSSIS volunteer does not always cease with graduation, but can continue after students return to their home countries or after they enter the Australian workplace.

The VLSSIS aims to contribute to international understanding and the mutual acceptance of people in the current global environment. A Thai student reflected: *I think this programme is one of the strategies to create strength in society.*

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BIOGRAPHIES

Josephine Sando has been Teaching English to Speakers of Other Languages (TESOL) since the early 1970s. In that time, she has worked in tertiary institutions in Australia, Sweden, Taiwan and the Solomon Islands. Since 1994, she has been employed by the University of Adelaide and has taught in a wide range of academic English programmes for international students. At present, she is a lecturer in the Centre for Learning and Professional Development (CLPD) and coordinator of the CLPD Volunteer Learning Support Scheme for International Students (VLSSIS), which now involves 60 volunteers. The VLSSIS is an enterprise that has given her a great deal of satisfaction.

Ron Seidel holds a degree in electronic engineering and postgraduate qualifications in computer science and education. He has had some 40 years of experience in teaching engineering and in educational management.

Formerly the Executive Manager of the Faculty of Engineering at Regency Institute and now retired, he has been a volunteer in Volunteer Learning Support Scheme for International Students (VLSSIS) at the University of Adelaide for six years, working with mostly postgraduate international students on a group and an individual basis. Based on his experiences in the VLSSIS and in the broader engineering community, his present research interest relates to issues facing international graduates in obtaining professional employment in Australia.

Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

Collaborative Learning in Engineering Education*

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Collaborative learning has been defined in a number of ways, but is generally understood to refer to small group learning where the group members actively support the learning processes of one another. Collaborative learning is increasingly recognised as giving students an opportunity to engage in discussion and to exercise a positive influence on the group's learning outcomes by assuming responsibility for their own learning. Critical thinking and reflective evaluation are implicit in the approach. In this article, the authors reflect on these general aspects and discuss their own experiences in employing *collaborative learning* techniques in their teaching. These include group work in laboratories, short-term team projects in engineering courses and capstone team projects in the final year of the programme.

INTRODUCTION

The notion of collaborative learning alludes to learning within groups that have been formed for the specific purpose of achieving set educational goals. Groups are small, normally not exceeding five members, and are purposed to be conducive to achieving a successful learning outcome that may be demonstrated by the acquisition of knowledge and skills or the completion of a set task. Collaborative learning has been hailed as giving *students an opportunity to engage in discussion, take responsibility for their own learning, and thus become critical thinkers* [1][2].

The main domain of application of collaborative learning seems to have been in primary and secondary education for which there is a mature research base. However, the well established principles are equally – even more aptly – applicable to tertiary education, especially so in the case of engineering education. Yet the body of literature reporting research outcomes/experiences from tertiary education appears modest in comparison [3].

*A revised and expanded version of an Opening Address presented at the *10th UICEE Annual Conference on Engineering Education*, held in Bangkok, Thailand, from 19 to 23 March 2007. This paper was awarded the UICEE Best Paper Bronze (Fifth Grade) Award by popular vote of Conference participants for the most significant contribution to the field of engineering education.

COLLABORATIVE VERSUS *COOPERATIVE*

There has been a lively debate about the *tag* attached to the learning paradigm that involves the active participation of *learners* in a small group towards achieving learning outcomes [4]. Is it *cooperative* learning or, more aptly, *collaborative* learning?

The dictionary definitions of these terms are as follows:

- Collaborate = work jointly (from Latin *collaborare*);
- Cooperate = work or act together (from Latin *cooperari*) [5].

So it should come as no surprise that there is some *murkiness* in the use of the terms to describe the object of the paradigm [6]. It has been argued that:

> *Collaboration is a philosophy of interaction and personal lifestyle whereas cooperation is a structure of interaction designed to facilitate the accomplishment of an end product or goal* [4] (underline added by the authors for emphasis).

The authors of this article confess to having succumbed to the *fuzziness* or *murkiness* of the difference between the words, both of which describe individuals *working together with the intent of enhancing learning outcomes for all involved* and hence will adopt the adjective *collaborative* with reference to small-group learning in discussing the notion further in this article.

Of further note is the use of the word *group*, which will be used alternately with the word *team* to denote a small number of individuals joined together for the pursuit of a common goal.

Notwithstanding the semantic nuances, both tags signify a major change from the previously prevailing learning paradigms, shifting the responsibility for learning from the teacher to the learner in a *team* united in purpose to improve learning outcomes however they are defined.

Figure 1: The notion of *collaboration* as depicted on the dome of Swiss Parliament [9].

SO, WHAT IS *COLLABORATIVE LEARNING*?

There seems to be a plethora of views as to what constitutes *collaborative learning*. These range from the notion of small group learning [4] to learning within the confines of a class and beyond, exceeding the boundaries of local teaching and learning entering into the domain of distance learning where the computing and information technology increasingly assume a dominant importance [7][8]. For the purposes of this article, the authors adopt the definition of collaborative learning as being a learning approach, which favours deep learning within a small team environment, where the individual team members unselfishly strive to contribute their utmost towards achieving the best learning outcomes for the team. In a way, this smacks of the principles of comradeship embedded in the dictum *Unus pro Omnibus. Omnes pro Uno*. This unofficial motto of Switzerland is equally cherished and valiantly advocated in many parts of the world, especially in Europe and North America (Figure 1).

It has been postulated that there are five major elements in this type of *team* learning, namely:

- Positive interdependence;
- Promotive interaction;
- Individual accountability;
- Use of interpersonal skills;
- Monitoring of progress [10].

Positive interdependence alludes to the belief that the group can succeed if all group members pull their weight towards achieving their common goals. *Promotive interaction* ensures that group members encourage and help one another to move forward. On the other hand, every member of the group is responsible and *individually accountable* for the group's learning outcomes whichever way they may have been defined. Evidently, *interpersonal skills* are critically important to the success of the group's endeavours: to succeed as a group, the members must trust and respect one another, communicate well and know how to handle conflict. For the group to have a genuine sense of achievement, there has to be some serious monitoring of progress based on achieving the milestones in a realistic schedule of activities agreed upon by the group and sanctioned by their *teacher* [10].

So, in a nutshell, when collaborative learning is adopted, competition is out and collaboration is in! This may sound as if the collaborative learning paradigm does not provide an environment for growth for the exceptionally talented, but that is not so! This is because those with greater talent than the rest still thrive by being a leading influence on their peers in the team. Furthermore, competition between several groups provides another proving ground.

WHY DOES IT WORK?

Cooperative learning works for more than one reason. Firstly it engenders a *team spirit* in members of the group. This motivates the more capable students in the group to help those struggling with the concepts. Similarly, the less able students develop a consciousness that they owe it to the team to pull their weight – so to say! Also, while helping their weaker team members, those with a better grasp than the rest may discover that they need to add to their knowledge for greater mastery. This in turn may inspire others in the group to widen their knowledge base. The shared responsibility for the team's destiny may compel everyone in the team to meet their obligations in terms of meeting assessment deadlines whether it be reports, milestones or other deliverables. Furthermore, cooperative learning is firmly based on *doing*! As such, it constitutes *active learning* [11].

RELEVANCE TO ENGINEERING EDUCATION

It is arguable that

> *… the advances in technology and changes in the organisational infrastructure put an increased emphasis on team work within the workforce. Workers need to be able to think creatively, solve problems, and make decisions as a team* [1].

Interestingly, this is exactly how engineers practise their profession! The notion of *collaborative* work is inextricably anchored in engineering practice. By and large, engineers do not work in isolation. It is inconceivable to think that great engineering projects of high complexity, whether it be a rapid transport system or satellite communication network, can be conceived and created by an engineer in solitude. Consequently, *collaborative learning* is most suited and a natural must in preparing engineering students for the challenges that lie ahead.

CHALLENGES

Despite the anticipated benefits of collaborative learning approach, engineering educators have to be prepared for a number of challenges when adopting collaborative learning strategies. They must appreciate that students entering into university engineering programmes come from vastly different educational, cultural and personal backgrounds. Students will have their favourite learning styles and will process the information they receive in different ways which must be accounted for.

Setbacks are inevitable once the collaborative learning paradigm has been adopted as the main stay of teaching and learning [11][12]. If a group is wavering, it is best to continue to provide as much support as is reasonable. This involves maintaining close contact with the group, making sure that the group has clearly defined goals, monitoring progress and inculcating self discipline as a prime ingredient for success. As a last resort, a *team leader* may be appointed.

BENEFITS

There is arguably a substantial number of benefits to be derived from adopting a collaborative learning strategy in education. First of all, the participants *learn to learn*. They acquire the skill of critical thinking, along with enhanced motivation, shared responsibility for learning, and learning by all, including the teacher, all of which contribute to building confidence and self esteem. Teamwork provides a better understanding of the subject for team members, providing stimulation in the thinking process. Shared responsibility for producing the group's deliverables has the effect of reducing the anxiety linked to the task. The right dose of humour is also seen to have stress reducing effect for the team members.

Evaluations of the effectiveness of the collaborative learning approach in university programmes in science, mathematics, engineering and technology programmes encourages its more widespread implementation [1][13].

SOME NEGATIVES

Some negative experiences are also noted that stem from personality clashes and irresponsibility within groups. For instance, group decision-making can be dominated by individuals with strong personality traits who can persuade by talking loudly and long, which can possibly intimidate the group members with a more subdued personality. This would be contrary to one of the basic tenets of collaborative learning that everyone must be given an opportunity to contribute to the group's learning outcomes [1].

Adopting the collaborative learning mode may also lead to strong opposition and resistance on the part of some students. This is particularly the case if groups suffer from disparity.

Students with better scholastic and intellectual aptitudes may feel that their progress is retarded due to lack of worthwhile contribution from the weaker team members. The latter may become disheartened and feelings of inferiority may surface. All this may put the teacher under pressure to abandon the approach and to go back to the traditional lecture-based delivery of the course materials. This would constitute a regrettable loss for both the teacher and the learners [11].

TENETS OF COLLABORATIVE LEARNING

Tenets of collaborative learning are based on shared goals, teamwork, a willingness to keep learning, individual responsibility and self-discipline. Interestingly, these tenets are inclusive in the educational framework at the authors' own university, the University of South Australia (UniSA) in Adelaide, Australia, which has articulated a set of seven Graduate Qualities to be inculcated in its graduates as distinguishing characteristics. A graduate of UniSA:

1. *operates effectively with and upon a body of knowledge of sufficient depth to begin professional practice*
2. *is prepared for life-long learning in pursuit of personal development and excellence in professional practice*
3. *is an effective problem solver, capable of applying logical, critical, and creative thinking to a range of problems*
4. *can work both autonomously and collaboratively as a professional*
5. *is committed to ethical action and social responsibility as a professional and citizen*
6. *communicates effectively in professional practice and as a member of the community*
7. *demonstrates international perspectives as a professional and as a citizen* [14].

The University of South Australia was a forerunner in Australia in the development of a set of generic graduate qualities as early as in 1995. As indicated in Table 1, these *qualities* match remarkably well with the ten *generic attributes of a graduate* formulated by the Institution of Engineers, Australia (the accrediting body for engineering programmes in Australia) and the 11 *EC2000 Criterion 3 outcomes* of the Accreditation Board for Engineering and Technology (ABET) in the USA [15][16].

It stands to reason that collaborative learning provides the tools towards achieving a number of these qualities. Indeed, several of the above listed qualities are implicitly embraced in collaborative learning.

More recently, the notion of *collaborative learning* has been extended into the realm of *distance learning* due the rapid developments in computer technology and IT. Networked Computer-Aided Learning (CAL) strongly augments collaborative learning and its further proliferation into the domain of collaborative learning is a foregone anticipation.

Table 1: Mapping of UniSA Graduate Qualities with IEAust Generic Graduate Attributes and ABET Criterion 3 Outcomes [14-16].

UniSA [14]	IEAust [15]	ABET [16]
Body of knowledge	Ability to apply knowledge of basic science and engineering fundamentals (IEAust 1) In-depth technical competence in at least one engineering discipline (IEAust 3)	Ability to apply knowledge of mathematics, science and engineering (ABET a) Ability to design and conduct experiments (ABET b) Ability to use the techniques, skills, and modern engineering tools necessary for engineering practice (ABET k)
Life-long learning	Expectation of the need to undertake lifelong learning, and capacity to do so (IEAust 10)	Recognition of the need for, and an ability to engage in, life-long learning (ABET i) Knowledge of contemporary issues (ABET j)
Effective problem solver	Ability to undertake problem identification, formulation and solution (IEAust 4) Ability to utilise systems approach to design and operational performance (IEAust 5)	Ability to design a system, component and process to meet desired needs (ABET c) Ability to identify, formulate, and solve engineering problems (ABET e)
Work alone and in teams	Ability to function effectively as an individual and in multidisciplinary and multicultural teams, with the capacity to be a leader or manager as well as an effective team member (IEAust 6)	Ability to function on multidisciplinary teams (ABET d)
Ethical action	Understanding the principles of sustainable design and development (IEAust 8) Understanding of professional and ethical responsibilities and commitment to them (IEAust 9)	Understanding of professional and ethical responsibility (ABET f)
Effective Communication	Ability to communicate effectively, not only with engineers but also with the community at large (IEAust 2)	Ability to communicate effectively (ABET g)
International perspective	Understanding of the social, cultural, global and environmental responsibilities of the professional engineer, and the need for sustainable development (IEAust 7)	The broad education necessary to understand the impact of engineering solutions in global and societal context (ABET h)

COLLABORATIVE LEARNING AT THE UNISA

The authors have employed the collaborative learning paradigm in their own teaching at the UniSA. The modes they used have included, *inter alia*:

- Group work in laboratories;
- Short-term team projects in engineering courses;
- Capstone group projects in the final year of the programme.

Project-Based Laboratory Work

At the School of Electrical and Information Engineering (EIE) at the UniSA, traditional laboratory work involving a sequence of practical sessions in the course *Introduction to Electrical Engineering* has been replaced by project work. In this first semester course in the first year of the programme, groups of two to three students are given the task of producing an operational piece of equipment, currently an electronic power supply (Figure 2). This necessitates familiarisation with the underlying theory and existing practices, getting to know the components, and developing manual skills such as soldering and assembling. The fundamentals were covered during scheduled formal lectures.

After final assembly, the power supply is tested to ascertain compliance with the system specifications. As a sequel, the power supply thus produced is used in the follow-up course, *Principles of Computer Systems*. This provides an additional incentive to the collaborative learning process since the evidence of success is practically demonstrable beyond the term of the effort. In addition, this experience early in the programme constitutes a critical stage in the successful transition to university studies.

Figure 2: A project-based laboratory.

Coursework Projects

A collaborative learning framework is the basis for a number of postgraduate and advanced undergraduate courses in the programmes offered by the School of Electrical and Information Engineering at the UniSA. In these, groups of up to five students work together on a class project. Groups are formed either by the course coordinator on his/her discretion or by the students. Even when the groups are formed by the course coordinator, students' views and wishes are taken into account in group formation. Special emphasis is laid on group heterogeneity, considering such factors as gender, ethnicity, socio-economic background, academic ability and practical skills.

As an example, assessment in mechatronics courses in the Electrical and Mechatronic Engineering stream is mainly based on the completion of a project that requires a mobile robot to be designed, built, tested and demonstrated. Students working in groups of three to five have some 11 weeks during which to conceptualise, design, manufacture and test their robot before they demonstrate it in competition with other teams. Teams have to employ engineering skills and system design techniques towards achieving their goal. The objective and the competition rules vary from year to year. They are jointly decided with participation by the whole class and form the basis of grading of the groups' efforts. All groups take part in the peer assessment of the oral presentation and robot performance on the day of competition (Figures 3 and 4).

The results have been encouragingly and consistently positive. Students enjoy the latitude they are given in developing their learning outcomes collaboratively and evidence it by quality achievements. This has been confirmed by student evaluations.

Figure 3: A group of students with their mobile robot on competition day.

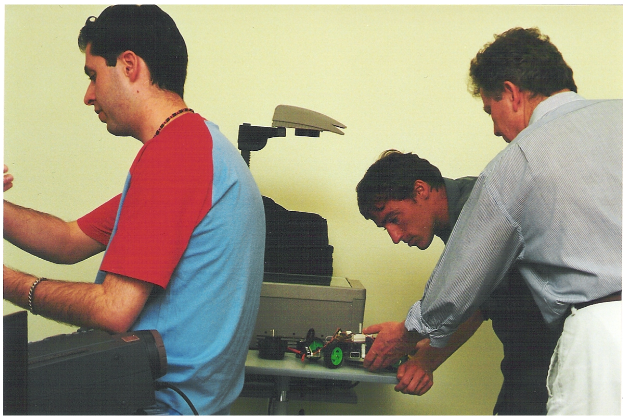

Figure 4: Setting up a mobile robot for demonstration.

Final Year Projects

Final year projects constitute the *capstone* in the four-year degree and five-year double degree programmes run by the School of EIE. These are undertaken collaboratively by groups of normally three students over two study periods of 13 weeks each. Students either choose their topic from a list of mainly multidisciplinary projects or initiate a project to match their own interest and aspirations. A brief project specification is produced for each proposed project, which includes an initial problem statement, skills required, resources available, and sponsor and contact details for further information. Alternatively, the group may develop the project topic in consultation with an industry sponsor. Some 80% of the projects in the School of EIE are industry sponsored with intense involvement with the industry supervisor.

Both the project choice and group formation are subject to negotiation and approval. Once approved, students have a great deal of autonomy and access to resources including manufacturing assistance, albeit under a strict regime in that all processes are to be based on systems engineering principles and standards. Teams must meet regularly, by themselves and with their supervisors, they have to keep formal meeting records, and must maintain a logbook. Each team must submit a project plan at the end of the fifth week which must contain an assessment agreement, statement of work to be undertaken, a project schedule, cost analysis, product testing method, system deliverables comprising documentation and the product, risk management and the group's organisational structure describing the individual responsibilities of the team members.

As a rule, teams work well and produce quality work, which is often taken up by industry partners for further development. An example is that of the design, manufacture and commissioning by a group of three final year students of a giga-Hertz transverse electromagnetic (G-TEM) cell for electromagnetic interference measurements (Figure 5).

CONCLUSION

The collaborative learning approach is intrinsically linked to many of today's highly held educational paradigms touted as the *world's best practice*. Such include active learning, student-centred learning, problem-based learning and project-based learning. Upon closer scrutiny, one can not avoid the inevitable conclusion that *collaborative learning* is the obvious natural choice for engineering education.

Figure 5: The completed G-TEM cell.

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BIOGRAPHIES

Özdemir Göl has had extensive experience as an engineering educator in addition to his substantial industrial experience. His academic career has included appointments in electrical engineering at universities in Turkey and Australia. He is the holder of MESc, ME and PhD degrees, all in electrical engineering. He is currently Associate Professor and discipline head of Electrical Engineering at the University of South Australia. His research interests have been focused on electrical machines and drives, and include the modelling and simulation of electrical machines using numerical methods and application of mathematical techniques to design the optimisation of electromagnetic devices. He is particularly interested in the design and development of novel electromechanical energy conversion devices, which integrate emerging active materials and non-conventional topologies.

He has a strong interest in innovative approaches to engineering education and has published widely in this field. His teaching responsibilities have included courses in electrical machines, engineering design and virtual instrumentation. He is the author and co-author of some 200 publications and recipient of numerous national and international awards of excellence for his work.

Andrew Nafalski's career spans several decades in academic and research institutions in Poland, Austria, the UK, Germany, Japan and Australia. He holds BEng(Hons), GradDipEd, MEng, PhD and DSc degrees. He is a Chartered Professional Engineer and Fellow of the Institution of Engineers, Australia, Fellow of the Institution of Engineering and Technology (UK), Senior Member of the Institute of Electrical and Electronic Engineers (USA) and Honorary Member of the Golden Key International Honour Society. He is currently a Professor of Electrical Engineering at the University of South Australia in Adelaide, Australia, and Professor of Information Technology and Computer Science at Lublin University of Technology, Lublin, Poland.

His major research interests are related to electromagnetics, information technology and innovative methods in engineering education. His teaching areas cover the analysis and design of electrical circuits and devices, electromagnetic compatibility and information technology. He has published some 275 scholarly works in the above fields including 21 books, monographs and software sets, 77 journal articles and 177 conference papers. He was the leader of some 40 technical and educational research and development projects attracting over AUD1,700,000. He has received numerous national and international awards for excellence in research, teaching, engineering education and community service.

Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

Higher Education Reform – the Societal Response to New Realities and Challenges*

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Although the higher education reform currently under preparation in Lithuania is provoking discussions in the academic community, there is nevertheless unanimous agreement concerning its aims: a higher quality of studies and better funding. It is a national imperative to transform the Lithuanian higher education system for the 21st Century and the state is responsible for designing the goals and strategies to accomplish that. Higher education is the gateway to the modern development of each country. To achieve these aims, the working group at the Lithuanian Ministry of Education and Science prepared a draft plan for the reform and development of higher education. The draft plan consists of several guidelines for the reform of funding, improvement of internal management in higher education institutions and use of resources, and conformity of study programmes to the labour market. It was proposed in the draft plan of higher education development that the internal management of higher education institutions should be revised and study programmes should aim for quality, not quantity. The fragmentation of study programmes should be stopped and faculties should be enlarged. Studies of the same field should be concentrated in one faculty and not scattered across several faculties. This would ensure the better use of intellectual and material resources. Designers of the draft plan are raising the issue of the size of state universities and colleges and their distribution in towns, since it is hardly expedient to maintain several similar higher education institutions in the same town. The active cooperation of employers and higher education institutions is encouraged. According to the reform plan, employers and students should actively participate in councils of higher education institutions and should be involved in the design of study programmes to ensure the training of skills needed in the labour market.

INTRODUCTION

On 12 November 2002, the Parliament of the Republic of Lithuania passed a resolution to approve the Long-Term Development Strategy of the State. The Strategy projects the development of Lithuania as a future European Union (EU) member state by identifying three priority areas: a knowledge society, a secure society and a competitive economy. The role of education in this development is of exceptional importance. In the Presidency Conclusions of the Lisbon Summit of 23-24 March 2000, the EU Council underlined the direct link of the continuing economic and social progress in the EU and its investment into people and their education:

> *People are Europe's main asset and should be the focal point of the Union's policies. Investing in people and developing an active and dynamic welfare state will be crucial both to Europe's place in the knowledge economy and for ensuring that the emergence of this new economy does not compound the existing social problems of unemployment, social exclusion and poverty.*

Education should contribute to the following:

- Strengthening the creative powers of a society;
- Protecting and developing national identity;
- Nurturing a mature civil society;
- Increasing employment and market competitiveness;
- Reducing poverty and social exclusion.

*A revised and expanded version of a lead paper presented at the *11th Baltic Region Seminar on Engineering Education*, held in Tallinn, Estonia, from 18 to 20 June 2007.

Higher education is vital to the success of a country's citizens, and national economic vitality and competitiveness. Higher education has always been a state responsibility and it must remain that way.

Moves to develop education should take into account new challenges and opportunities for society, such as the development of democracy and the market economy, the process of globalisation, the vast amounts of information, rapid changes and the fragmentation of society. Education should help an individual and society at large to respond to these challenges and to take advantage of new opportunities. This necessitates essential reforms in the educational system in order to increase its efficiency, improve accessibility to education, create conditions enabling continuing education and life-long learning, ensure the quality of education that conforms to European standards and meets the needs of modern society.

In light of the challenges faced by society today, as well as taking into account that a knowledge society, a secure society and a competitive economy are defined as priorities in the Long-Term Development Strategy of the State, the mission of education is as follows:

- To help an individual to understand the contemporary world, to acquire cultural and social competences and to become an independent, active and responsible person who is willing and able to learn and create a life of his/her own and the life of society;
- To help an individual to acquire a vocational qualification corresponding to the level of modern technologies, culture and personal skills, and to create conditions enabling life-long learning, which encompasses the continuous satisfaction of cognitive needs, seeking to acquire new competences and qualifications that are necessary for the professional career and meaningful life;
- To ensure the balanced and knowledge-based development of the economy, environment and culture of Lithuania, the domestic and international competitiveness of the economy, national security and the evolution of a democratic society, thus strengthening the creative powers of society.

Education should help society to achieve the following strategic goals:

- To create and develop a knowledge-based competitive economy;
- To develop the democratic culture of the country;
- To achieve a substantial reduction of social exclusion and poverty;
- To ensure the employment of people;
- To nurture solidarity in a civil society;
- To strengthen national security;
- To preserve national identity.

The Strategic Provisions shall be used as tools to mobilise the efforts of different stakeholders, state institutions and non-governmental organisations, students and their parents, educators, employers and politicians. The Provisions are targeted at the implementation of long-term goals in the area of updating the system of education.

In January 2005, the Lithuanian Government approved the Implementation Programme for the Provisions of the National Education Strategy 2003-2012. This Programme highlights strategic guidelines for educational reform and provides the implementation measures and resources in line with the Lisbon Strategy. This programme was developed in line with the Long-Term Economic Development Strategy of Lithuania until 2015 (2002) [1], the Single Programming Document for Lithuania of 2004-2006 (2004) [2], as well as the European Memorandum on Lifelong Learning [3], the European Employment Strategy [4], the Bologna Declaration [5], the main objectives for the educational development of European Union Member States until 2010, raised by the European Commission, Provisions of National Education Strategy 2003-2012 [6] plus other documents.

The Lithuanian State and society shall seek to achieve the following key aims for developing education in 2003-2012:

- To develop an efficient and consistent education system that is based on responsible management, targeted funding and the rational use of resources;
- To develop an accessible system of continuing education that guarantees life-long learning and social justice in education;
- To ensure a quality of education that is in line with the needs of an individual living in an open civil society under market economy conditions, and the universal needs of society in the modern world;
- Every citizen should have the possibility to study at a higher school in a chosen mode of study (distance, extramural or other), and more than 60% of Lithuanian youth acquire higher university or non-university education;
- The Lithuanian people should have genuine opportunities for life-long learning, the continuous updating and development of their abilities; every year, at least 15% of the working age adult

population should undergo some kind of training or educational activity;
- At least 85% of the working age population should have real opportunities and capabilities to use computer information technologies.

Lithuania's current three-tier educational system was implemented in 1991-1992. The law introducing a binary system came into force in September 2001 [7]. After successfully completing the first basic, four-year-duration studies, students are awarded a Bachelor's or Engineer's degree. The second tier after Bachelor's, covering two years, leads to a Master's degree or after one year if a Bachelor's diploma engineer's degree has already been awarded. The third tier comprises four-year doctoral studies after the Master's degree.

From 1991-1995, higher education institutions (HEIs) developed the majority of their study programmes, renewed the study content, and introduced compulsory modules of humanities and social subjects. This reform helped HEIs to survive during the period of economic and social decline, when the number of students decreased from 18 students/1,000 inhabitants in 1990-1991 to 14/1,000 in 1994-1995 [8][9]. After 15 years of transformation in Lithuanian HEIs, it is now possible to reflect back on these efforts [10][11]. Lithuanian higher education today has *consecutive* and *non-consecutive* types of studies. After completing a study programme, a person is awarded an academic or a qualification degree. Consecutive studies at technical higher education institutions can be of two types, namely:

- University, when an individual is given higher education based on a wide theoretical background and scientific investigation;
- Non-university covering one-level professional studies intended for preparing students for professional activities. An individual acquires professional qualifications on the basis of applied scientific investigation or applied research.

Upon completing consecutive studies, an individual receives an academic certificate (diploma). An individual enrolled in non-consecutive studies and having collected a sufficient number of credits within a study programme, can also be considered as having completed studies at a higher education level. The study level is a classificatory parameter of study programmes, which is defined by the level of complexity of the programme, the rank of the awarded qualification in the national system of qualifications and other indicators. The first level of studies is aimed at expanding one's general education, providing knowledge and skills that would allow one to start professional activities and creatively apply accumulated knowledge and skills. The second level of studies is aimed at preparing individuals for careers in science and careers requiring scientific knowledge and skills.

After 15 years of operation, the accepted system showed shortcomings and the result was discontent from society and the universities. Although the higher education reform being prepared is provoking discussions in the academic community, there is, nevertheless, unanimous agreement regarding its aims, specifically: a higher quality of studies and better funding. In order to achieve these targets, the working group at the Lithuanian Ministry of Education and Science has prepared a draft plan for the reform and development of higher education [12]. The draft plan consists of several guidelines: a reform of funding, the improvement of internal management at higher education institutions and the use of resources, and aligning study programmes to the labour market.

PREFACE TO NEW EDUCATIONAL REFORMS

Higher education in Lithuania can be acquired only at higher education institutions. They offer non-university-type and university-type studies. Non-university studies are basic, one-cycle studies. University studies consist of three cycles: first cycle (undergraduate studies), second cycle (Master's studies, special professional studies) and third cycle (doctoral studies, MDs in residency and art licentiate). The quality of study programmes, as well as the quality of research and pedagogical activity carried out by higher education institutions, is periodically assessed by the Centre for Quality Assessment in Higher Education. In promoting the quality of studies, special attention is devoted to the regulation, external assessment and accreditation of the structure and content of study programmes. In 2004 alone, the external consecutive assessment of 91 study programmes was performed, out of which 29 study programmes were assessed by foreign experts, 50 study programmes were accredited, and 32 new study programmes were included into the Register of Study/Training programmes.

The Ministers responsible for higher education in the signatory states of the Bologna Declaration have entrusted the implementation of all the issues covered in the Berlin Communiqué, the overall steering of the Bologna Process and the preparation of the next ministerial meeting to the Bologna Follow-up Group (BFUG). In accordance with the latest BFUG document prepared for ministers for the London Summit, the implementation of the Bologna principles at Lithuanian HEIs looks quite well (see Table 1).

Nevertheless, over several years, opinions expressed in the mass media escalated: the state of higher education is unsatisfactory, the quality of education is down, many academics are over age, the university management model is out-of-date

Table 1: The Bologna process stocktaking 2007.

Indicator	Implementation in Lithuanian HEIs	
	Score (max 5)	Results
Degree System		
1. Stage of implementation of the first and second cycle	5	In 2006/2007, at least 90% of *all* students are enrolled in a two-cycle degree system that is in accordance with the Bologna principles
2. Access to the next cycle	3	There are some (less than 25%) first cycle qualifications that do not give access to the second cycle and/or some second cycle qualifications that do not give access to the third cycle
3. Implementation of a national qualifications framework	2	The development process leading to the definition of a national Qualification Framework (QF) in line with the overarching QF for the European Higher Education Area (EHEA) has started and includes all relevant national stakeholders
Quality Assurance		
4. National implementation of *Standards and Guidelines for QA in the EHEA*	4	The process of implementing a national Quality Assurance (QA) system in line with the *Standards and Guidelines for QA in the EHEA* has started
5. Stage of the development of an external quality assurance system	5	A fully functioning quality assurance system is in operation at the national level and applies to all HE. The evaluation of programmes or institutions includes three elements: internal assessment, external review and the publication of results. In addition, procedures have been established for the peer review of national QA agency(ies) according to the *Standards and Guidelines for QA in the EHEA*
6. Level of Student and International Participation		
6a Students	5	Students participate at four levels: - In the governance of national bodies for quality assurance; - In external reviews of HEIs and/or programmes in expert teams or observers in expert teams or at the decision making stage; - In consultation during external reviews; - In internal evaluations
6b International	3	International participation takes place at two of the four above levels
Recognition of Degrees and Study Periods		
7. Stage of implementation of the diploma supplement	5	Every student graduating in 2007 received a diploma supplement in the EU/CoE/UNESCO diploma supplement format and in a widely spoken European language (English) automatically and free of charge
9. Stage of implementation of ECTS	4	In 2007, credits are allocated in at least 75% of the first and second cycle higher education programmes, using ECTS or a fully compatible credit system enabling credit transfer and accumulation. A *translation* between the national system and ECTS is obligatory
Life-Long Learning		
10. Recognition of prior learning	4	There are procedures/national guidelines or policy for the assessment of prior learning but they are used for only one of the abovementioned purposes
Joint Degrees		
11. Establishment and recognition of joint degrees	4	There are no legal or other obstacles to establishing joint programmes and the awarding and recognition of joint degrees or at least double or multiple degrees (a double or multiple degree is defined as two or more diplomas issued by two or more higher education institutions involved in an integrated study programme), but legislation does not specifically refer to joint degrees or legislation for establishing joint programmes; the awarding and recognition of joint degrees has been prepared and agreed, but not yet implemented

(pro-Soviet), corruption at universities is flourishing and obscure financial operations are pursued. While continuously receiving such information, it seems that universities in Lithuania are the main setback to the new, modern existence.

DEVELOPMENTS AT HIGHER EDUCATION INSTITUTIONS OVER THE LAST DECADE

The student population at Lithuanian universities doubled from 1997-1998 until 2005-2006, whereas financial support for one student (in GDP%) halved. The university student population gradually reached 54 students/1,000 inhabitants.

Before Lithuania was admitted into the EU, the unemployment ratio was quite high, and government and society observed the extensive growth of the student population positively without negative emotions. In this period, the societal opinion formed that higher education was *obligatory* for youths' successful careers. This pressure was responded by universities with options for study that was free of charge, partly paid or fully paid. However, the growing student population encountered worsening study facilities and quality of studies. Technicums – institutions for middle range professional education – were swept out from the professional education panorama. These institutions become higher non-university level education institutions offering Bachelor and Master's degree education.

Entrance into the EU coincided with the growth of labour force emigration and the economy facing a shortage of labour resources. Business, industrialists and politicians started discussions about the necessity of study reforms, publications appeared asserting that higher education reform had never started and the situation emerged revealing guilty rectors of universities. In this avalanche of accusations, political parties totally forgot about signed memoranda with obligations to support the quality assurance of study through adequately rising higher education financing.

Many European countries are significantly improving their higher education performance. They are prioritising higher education in their national public agenda and are approaching higher education reform as part of a national economic development strategy [13]. The Lithuanian higher education system is not sufficiently ready to prepare students for the challenges of 21st Century society. Universities are not taking globalisation seriously. Globalisation demands different priorities, different skills and different knowledge. Today's students differ significantly from those of yesterday. Only part of those students in the higher education system fit the model of the *traditional* student. Many attend part-time studies and have matched studies and jobs. Today's students include older and returning students. Yet policy decisions still focus primarily on the traditional student.

THE CURRENT MODEL OF UNIVERSITY MANAGEMENT

The management model at all Lithuanian university-type HEIs is similar. The *University Board* supervises all the university's activities and is responsible for ensuring that university tasks are properly fulfilled. The rector is a Board member. By the order of the Minister, the membership of the Board is confirmed and *its Chairman is appointed taking into account the proposals of the rector*. The Chairman of the Board cannot be a university staff member. The Board acts according to the confirmed regulations and should make decisions on, and recommendations about, the university's development plan and university-Ministry agreements. The Board should also announce the elections of the rector or senate and should submit an annual report to the Minister about the university's activities.

The university senate is the highest decision-making body of a university. The university senate is authorised to elect a rector (and to impeach him/her if necessary), to adopt by-laws regulating the process of education, research and financing, and provide a yearly report on the university's activities. At least 10% of senate members must make up students appointed by the Students' Representation.

PIVOTAL POINTS OF THE REFORM AND BACKGROUND TO FUTURE REFORMS

The draft plan of guidelines prepared by the working group define more clear state goals, identify the state's strengths and weaknesses, rethink funding and the student aid system, estimate demographic trends, etc. Lithuania needs long-term priorities for higher education that links higher education to overall state economic goals. It is difficult to articulate meaningful goals for state higher education systems without good information about upcoming population changes for the next 10 to 20 years.

Over the years, states have reduced their share of overall higher education costs; as a result, the share of costs for students, families and institutions has gone up. States should examine their financial aid programmes to ensure that they are well balanced and reward efficient students.

However, ensuring that students get into higher education institutions is only half the problem. States should also ensure that students graduate. Study system reform should encourage innovation within the entire state higher education community. Adults going back to universities or colleges now represent a growing number of the student population and they have different needs than traditional students.

The new order should ensure that state money is spent productively with the demand that institutions become more efficient. Higher education institutions are expected to deal with a number of tasks of high importance for the country's economy, culture, welfare, environment and democracy. At the same time, they are required to contribute to education and research of immediate benefit to working life in both the public and private sectors. New legislation should help communication with business to better articulate expectations and outcomes. A 21st Century education system should support opportunities for all citizens to participate in some form of post-secondary education or training.

The internal management of higher education institutions should be revised and study programmes should target quality, not quantity. The fragmentation of study programmes should be halted and faculties should be enlarged. Studies of the same field should be concentrated in one faculty and not scattered across several faculties so as to ensure a better use of intellectual and material resources.

International experts will be invited to evaluate the activities of universities in different fields of studies. Centres of excellence will be identified and Master's and doctoral studies will be concentrated there. Designers of the reform have raised the issue of the size of state universities and colleges and their distribution in towns, since it is hardly expedient to maintain several similar higher education institutions in the same town.

The design and use of the financing model for universities and colleges must support major educational and research policy goals and strategies. Quality considerations in education and research are best safeguarded by means of a financing system that emphasises the results attained. Control arrangements must result in better assurance that educational institutions develop and follow up quality development strategies in education and research, and that they make efficient use of their resources.

In order to safeguard considerations regarding long-term research activities, the breadth of academic provisions and the maintenance of costly disciplines, the reform draft emphasises that a performance-oriented component of the financing of research and teaching must be supplemented by the introduction of the basic financing of educational institutions as an additional budget component.

The draft plan foresees tax advantages on study loans for young specialists employed in Lithuanian enterprises. They would get a tax refund to cover the costs of the loan. Another aspect of the funding reform is a reduction of the duration of studies. The suggestion is that, in general, both cycles (Bachelor and Masters) should not exceed five years. This duration of studies is recommended in the Bologna Declaration. A new common degree structure is proposed that involves a lower degree upon completion of three years of study (Bachelor) and a higher degree building on this to be awarded upon completion of a further 1.5-2 years of study (Masters). This higher degree builds on the lower degree, providing professional qualifications and/or the opportunity for admission to doctoral studies. Formal research training will continue to have the current duration of four years. There will be a need for two types of course: one resembling the traditional theoretically oriented Lithuanian university degree at the Master's level, the other more practically oriented (college degree). The first type of degree will qualify one for admission to formal research training while the second type will not necessarily do so.

All students should pay for their studies. The state settles the amount of the support per student (grant and loan) and the total number of students supported. Higher education institutions are free to set their enrolment rates, ie decide upon the total number of students and the cost of studies. The support scheme does not ensure that low-income students have access to higher education. Nevertheless, the Government's primary responsibility in higher education is to guarantee post-secondary education not for the wealthiest individuals, but for all citizens.

Under discussion are more aspects of university management, specifically:

- The election or nomination of rectors;
- The status of the university: state or public;
- The principles of Board nominations.

Those ministers responsible for higher education in the countries participating in the Bologna Process met recently in London in 2007 to review the progress made since meeting in Bergen in 2005. The London Communiqué declares that higher education should play a strong role in fostering social cohesion, reducing inequalities and raising the level of knowledge, skills and competences in society. Therefore, the governmental policy should aim to maximise the potential of individuals in terms of their personal development, and their contribution to a sustainable and democratic knowledge-based society. The student body entering, participating in and completing higher education at all levels should reflect the diversity of the population. The ministers reaffirmed the importance of students being able to complete their studies without obstacles related to their social and economic background [14]. Europe looks for educated young people and is against restrictions in higher education.

Reformers consider that Lithuanian higher education institutions should be at the forefront of academic cooperation and student exchanges between countries. It is seen as a goal that all higher education institutions should offer students a period of study abroad as a component of their Lithuanian degree course. It is likewise important that universities and colleges continue to develop their provision of courses held in English.

The reform stimulus in Lithuania takes the following path:

- Agreement among the government, President and political parties concerning the necessity of study and research reform;
- The government, society and business strive to create the nucleus of a knowledge economy;
- Revision of the Lisbon strategy, focusing on research and knowledge creation;
- Use of the financial tools of the 2007-2013 EU structural fund as sponsorship.

The components of the planned reform include the following:

- The strengthening of science and business interaction;
- The renewal of the research infrastructure;
- Human resources quality development;
- Research management system development;
- The reformation of the legal basis.

The system of state Lithuanian research institutes was reorganised several years ago. This reorganisation was aimed at promoting the integration of science and studies. A system of university research institutes was created allowing a more effective use of the national research potential for study purposes.

This new development of the research infrastructure will include the creation of a knowledge nucleus comprising studies, research and business valleys. These tasks will involve improved cooperation among research, business, government and municipalities; updated laboratory equipment in key sectors of research; revised research and study institutional networks (small units joined into larger ones, etc), implementation of the coordinated development of business incubators and technological parks. Research activities should be supported according to the research programmes and scientific projects based on competitive principles.

The part of national funding for research and studies is being increased within the state budget and is going to reach the *EU average* in the period of five years.

The following schedule of the reform has been announced:

- Announcement of the basic principles of reforms: 1 September 2007;
- Presentation of the scientific research sponsorship model: April-May 2007;
- Decision making: autumn 2007;
- Implementation: from the beginning of 2008;
- Implementation of the EU Structural fund sponsorship programme: from 2007-2008.

CURRENT SITUATION IN ENGINEERING STUDIES

Students at technical universities do not see the challenge in engineering and perceive it as dull. It is necessary to help students focus on real challenges that engineers face by providing creative problem-setting within the engineering courses. Real problems could be supplied by industry. In the engineering profession, is necessary to reflect continuously current reality and train students' abilities to become the next generation of engineers and to face an ever-changing future.

It is the responsibility of university staff to help students to develop the skills required for graduates of tomorrow and to ensure that technical universities do not lose the best students to other professions. There are students who fail during their studies due to a lack of motivation or application to their studies, or decide to change to another career path due a lack of interest or disillusionment in engineering (the dropout rate in engineering is close to 40-50%). Many engineering students have very low entrance grades and hence might be considered at high risk.

Relations between students and institutions must also be strengthened. Educational institutions must make provisions to enable the closer monitoring of students throughout their studies. This presents new challenges for educational institutions and a call for a critical approach to the content and structure of courses, as well as a competence policy.

CURRENT SITUATION IN HIGHER EDUCATION REFORM

There is no special national budget allocated for the new higher education reform for Lithuania in 2007. But some steps of the reform would not be expensive. Among these steps are the following:

- Restructuring of research management and financing;
- Establishment of a research council and applied research agency;
- Development of the mechanisms for research policy coordination;
- Preparation of the legal documents for reform.

However, those academics, who have been discussing the coming reform, have not been so enthusiastic. In 2007, salaries will be raised in the higher education system by around 10%, while salary increases in other areas of the economy will be about 15% as foreseen. So the de facto salaries of academics will increase less than the national Lithuanian average. As such, are academics really motivated to support this reform? Unlikely.

CONCLUSIONS

Lithuanian universities technically made a reform of the study system long ago, but from the viewpoint of teaching and learning strategies, as well as meeting new challenges, universities have lots of unfinished transformations and unsolved problems. Study reform is necessary because the Lithuanian higher education system is not preparing students for the 21st Century global society but is instead applying 20th Century policy solutions to a 21st Century world.

The main tasks of the reform are to strengthen science and business interaction, renew the research infrastructure, develop quality human resources, develop a research management system and reform the legal foundation.

The Lithuanian society is not prepared for the dramatically changing demographic shifts in the country's populations. Considerations of the impact of a decreasing birth rate and population (including emigration) are absolutely essential to the future higher education.

The Bologna Declaration, which declares the creation of the European area for higher education, was a good reason for the revision of the existing education model in Lithuania and has clearly stimulated the building of *bridges* between the sub-systems of higher education.

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BIOGRAPHY

Prof. Dr Habil Algirdas Vaclovas Valiulis was born in Vilnius, Lithuania, in 1943. In 1967, he was awarded a Mechanical Engineer Diploma and in 1974, he defended his PhD thesis. He was awarded his Doctor Habilitus degree in 1997. He has been a professor and an Expert member of Lithuanian Academy of Science since 1998.

Prof. Valiulis teaches fusion welding technology and equipment for ferrous and non-ferrous metals and polymers, materials science, soldering and brazing. His research interests are in arc, resistance, lasers, diffusion welding and the heat treatment of ferrous metals, as well as the curriculum development of study programmes.

From 1990-2006, he was a Vice-Rector of Vilnius Gediminas Technical University in Vilnius, Lithuania. Since 2001, he has been the Head of the Department of Materials Science and Welding, and the Dean of the Faculty of Mechanics at Vilnius Gediminas Technical University since 2006.

He has authored over 300 research, methodological, scientific and study organisation publications, including several books and textbooks, plus many study guides and manuals. He has also presented over 100 papers at international conferences. Prof. Valiulis is a member of the European Society for Engineering Education, European Association for International Education, national representative for Lithuania in the European Society for Engineering Education, European Commission Committee for Coal and Steel, a mirror group member of the European Steel Technology Platform, a member of the EC Bologna experts team, and chairman of the Lithuanian Welding Society.

In 2000, he was awarded the UICEE Silver Badge of Honour (2000) for *…distinguished contributions to engineering education, outstanding achievements in the globalisation of engineering education through the activities of the Centre, and, in particular, for remarkable service to the UICEE.*

Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

Laboratory Instruction in Engineering Education*

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Laboratory instruction develops students' experimental skills, ability to work in teams and communicate effectively, learn from failure, and be responsible for their own results. There are three types of educational laboratories in engineering education. The oldest one is known as a hands-on laboratory with real instruments, the second is a simulated or virtual laboratory, while the last one is a remote or distributed learning laboratory. The effectiveness of any type of a laboratory depends upon the learning objectives that are associated with the laboratory. The laboratory environments may already involve a blend of hands-on, computer-assisted and simulated tools. Last year, a few educational laboratories were renovated and modernised at the authors' respective institutions. These activities were carried out in accordance with the laboratory development plans of the institutions and were based on the needs of study programmes. The modernised laboratory is a challenge to the academic staff to develop new and more effective laboratory instruction. In developing the laboratory, students' attitudes towards laboratory instruction were taken into consideration as well.

INTRODUCTION

I hear and I forget;
I see and I remember;
I do and I understand.

Chinese proverb

Engineering education is inconceivable without laboratory instruction. There are three types of educational laboratories in engineering education [1]. These can be listed as follows:

- The oldest one is known as hands-on laboratory with real instruments;
- A simulated or virtual laboratory;
- A remote or distributed learning laboratory.

It must be pointed out, that most laboratory environments may already involve a blend of hands-on, computer-assisted and simulated tools.

Educational goals for any type of laboratory are considered as follows:

- *Conceptual understanding*: the extent to which laboratory activities help students understand and solve problems related to key concepts taught in the classroom;
- *Design skills*: the extent to which laboratory activities increases students' abilities to solve open-ended problems through the design and construction of new artefacts or processes;
- *Social skills*: the extent to which students learn how to productively perform engineering-related activities in groups;
- *Professional skills*: the extent to which students become familiar with the technical skills they will be expected to have when practicing in the profession [1].

These goals are the most applicable for a hands-on laboratory, while design and social skills are not so specific for the remote and simulated laboratories.

*A revised and expanded version of a lead paper presented at the 11th *Baltic Region Seminar on Engineering Education*, held in Tallinn, Estonia, from 18 to 20 June 2007.

The many aspects of the role of the teaching laboratory in engineering education were analysed by Feisel and Rosa in their paper published in the *Journal of Engineering Education* [2]. The authors presented a historical overview of engineering teaching laboratories, considered the application of computers in the laboratory to acquire data, analyse results, control and simulate experiments, and even use the Internet in order to provide students with remote access to instruments in a real laboratory. The authors also outlined the fundamental objectives of the engineering teaching laboratory. These objectives were formulated by some 50 distinguished engineering educators at the colloquy convened in San Diego, USA, in January 2002 and are cited below.

All the objectives start with the following: *By completing the laboratories in the engineering undergraduate curriculum, you will be able to...*

- *Objective 1: Instrumentation. Apply appropriate sensors, instrumentation, and/or software tools to make measurements of physical quantities.*
- *Objective 2: Models. Identify the strengths and limitations of theoretical models as predictors of real-world behaviours. This may include evaluating whether a theory adequately describes a physical event and establishing or validating a relationship between measured data and underlying physical principles.*
- *Objective 3: Experiment. Devise an experimental approach, specify appropriate equipment and procedures, implement these procedures, and interpret the resulting data to characterise an engineering material, component, or system.*
- *Objective 4: Data Analysis. Demonstrate the ability to collect, analyse, and interpret data, and to form and support conclusions. Make order of magnitude judgments and use measurement unit systems and conversions.*
- *Objective 5: Design. Design, build, or assemble a part, product, or system, including using specific methodologies, equipment, or materials; meeting client requirements; developing system specifications from requirements; and testing and debugging a prototype, system, or process using appropriate tools to satisfy requirements.*
- *Objective 6: Learn from Failure. Identify unsuccessful outcomes due to faulty equipment, parts, code, construction, process, or design, and then re-engineer effective solutions.*
- *Objective 7: Creativity. Demonstrate appropriate levels of independent thought, creativity, and capability in real-world problem solving.*
- *Objective 8: Psychomotor. Demonstrate competence in selection, modification, and operation of appropriate engineering tools and resources.*
- *Objective 9: Safety. Identify health, safety, and environmental issues related to technological processes and activities, and deal with them responsibly.*
- *Objective 10: Communication. Communicate effectively about laboratory work with a specific audience, both orally and in writing, at levels ranging from executive summaries to comprehensive technical reports.*
- *Objective 11: Teamwork. Work effectively in teams, including structure individual and joint accountability; assign roles, responsibilities, and tasks; monitor progress; meet deadlines; and integrate individual contributions into a final deliverable.*
- *Objective 12: Ethics in the Laboratory. Behave with highest ethical standards, including reporting information objectively and interacting with integrity.*
- *Objective 13: Sensory Awareness. Use the human senses to gather information and to make sound engineering judgments in formulating conclusions about real-world problems.*

These objectives of laboratory instruction are in line with ideas presented by Wankat and Oreovicz in their book, *Teaching Engineering* [3].

Such a set of fundamental objectives can be useful for the guidance of engineering educators to develop and evaluate the effectiveness of laboratory experiences. At least that is the case at Kaunas University of Technology (KUT) and Kaunas Technical College (KTC), both based in Kaunas, Lithuania.

LABORATORY INSTRUCTION AT KAUNAS UNIVERSITY OF TECHNOLOGY

Circuit Theory is the basic course in electronics engineering education. The main aim of such a course is to provide knowledge of the methods of mathematical modelling and of solutions for electric circuits, as well as to develop abilities and skills for practical applications.

Within the Faculty of Telecommunications and Electronics at Kaunas University of Technology, the *Circuit Theory* course is run by the Department of Signal Processing and is traditionally a two-semester course. Every week, students have classes for lectures (three hours), tutorials (two hours) and laboratory (one hour). The duration of a laboratory experiment is four hours. Therefore, students attend the laboratory once a month, or four times in total per semester. Students usually work in groups of two or three, but separate reports have to be prepared and presented to the instructor for individual assessment.

Last year, the Department of Signal Processing received a grant for the purchase of teaching equipment for *Electric Circuits Laboratory*. There was a temptation to use virtual instruments instead of real ones because of the lower cost [4]. However, that idea was rejected since computer simulations today still cannot effectively replace hands-on experiments [2]. Thus, the grant was used for the purchase of instrumentation as listed below:

- GDM-8246 - dual display digital multimeter by Instek (ACV measuring frequency up to 100 kHz): 6 units;
- GDS-806C - digital storage oscilloscope by Instek (60 MHz bandwidth with colour display): 5 units;
- GOS620 - analogue oscilloscope by Instek (20 MHz): 3 units;
- GFG-8219 - function generator with built-in counter by Flite Electronics International (3 MHz, INT/EXT AM/FM modulation, and LIN/LOG sweep mode): 4 units;
- Flite's IDL-600 Analogue Lab (a unique platform on which analogue electronic circuits may be constructed with ease. This unit contains a built-in multi-rail DC power supply, analogue voltmeter and ammeter, and a function generator along with a large area of breadboard, switches, indicators, potentiometers and a loudspeaker): 7 units;
- PCS500 - 2-channel PC scope by Welleman (1000 MS/s with adapter): 2 units;
- PCG10A - PC function generator by Welleman (standard waveforms: sine, square and triangle, plus a library of predefined waveforms: noise, sweep): 2 units;
- Personal computer: 4 units.

The types and quantity of instruments selected had to meet the objectives of the laboratory, but were limited by funds available for the purchase. A compromise was found. Therefore, the *Electric Circuits Laboratory* was renovated and eight workplaces were equipped with new educational instruments for hands-on experiments. Besides that, four computers are available for the analysis and processing of acquired data, as well as for demonstrations and some simple simulations. For the needs of laboratory instruction, *LabVIEW* software and *MATLAB* and *Mathcad* packages are available as well. The modernisation of the *Electric Circuits* teaching laboratory was based not only on the KUT's educational experience, but on the expertise of colleagues as well.

Currently there are 10 experiments, modernised or new ones, prepared for laboratory instruction in the *Electric Circuits Laboratory* as follows:

1. Instrumentation and measurement – introduction;
2. Experiments with DC circuits;
3. Properties of circuit elements;
4. The resonance of a series RLC circuit;
5. The resonance of a parallel RLC circuit;
6. Two-port network frequency response;
7. Operational amplifier as a circuit element;
8. Differentiation and integration circuits;
9. Transient response in RLC circuit;
10. Experiments with modern filters.

The list of laboratory experiments is not fixed or closed. The modernised laboratory is a challenge to academic staff to develop new and more effective laboratory instruction. In this activity, a few doctoral students and some undergraduate students are also involved. Not all of these experiments are compulsory. For some clever students, a few – or even all – experiments can be replaced by an individual project that is carried out in the laboratory.

Survey of Students

In order to evaluate the effectiveness of laboratory instruction in the *Electric Circuits Laboratory*, a questionnaire was developed and distributed among second year students who had one semester of experience in the laboratory. The questionnaires were filled out in the classroom and were aimed at obtaining individual students' responses. Students were asked to rank lectures, tutorials, laboratories and individual study in a sequence of decreasing importance, and define by grades their own academic performance in learning *Circuit Theory*.

Table 1: *Circuit Theory*; results of the survey on students' opinions on lectures, tutorials, laboratories and individual study. The smallest number (*m*) in a row indicates what the surveyed students regarded as the most important.

	Lectures m±σ	Tutorials m±σ	Laboratory m±σ	Individual study m±σ
Attractiveness of classes	2.38±0.98	2.13±0.76	1.75±0.95	3.75±0.59
Attendance at classes	2.95±0.22	2.00±0.32	1.05±0.22	
The most valuable classes/activities	3.12±0.80	1.57±0.67	1.86±0.93	3.45±0.74
Most effective learning at	3.12±0.81	1.34±0.53	2.17±0.97	3.37±0.77
Acquired knowledge/skills (%) (in total 100%)	19%	32%	26%	23%
Circuit Theory: hours/per week	3	2	1	4
Students' proposal: hours/per week	2.70±1.19	2.57±0.77	1.53±0.82	3.13±1.38

In all, 40 students took part in the survey. The results of the survey are presented in Tables 1 and 2. The numbers in these tables represent the mean *m* and the standard deviation σ of students' responses. The smallest number (*m*, underlined in the tables) in a row indicates what the surveyed students regarded as the most important. Table 3 presents the criterion-based grading system at the KUT and KTC.

The results of the survey shown in Table 1 demonstrate that attendance at the laboratory and attractiveness of the laboratory were rated the highest. This is understandable as the laboratory is equipped with modern instrumentation and laboratory classes provide students with first-hand experience in circuit theory concepts and with the opportunity to explore methods that are used by engineers in practice. Besides that, the laboratory is an ideal place for active learning [5]. Students learn in a real world environment, function as team members, discuss the planning of experiments, and share ideas about the analysis and interpretation of data.

Table 2: *Circuit Theory*; results of the survey on students' academic performance; the correlation coefficient of examination and laboratory assessment grades: r=0.49.

Student Performance at:	Average Grade as m±σ
Examination	6.83±1.52
Laboratory	8.15±1.25
Individual study/project	7.80±1.38

Table 3: The grading system at the KUT and KTC.

Pass/Fail	KUT/KTC Grade	ECTS Grade
Pass	10 (excellent)	A
	9 (very good)	B
	8 (good)	C
	7 (highly satisfactory)	D
	6 (satisfactory)	D
	5 (sufficient)	E
Fail	4 (insufficient)	FX
	3 (highly insufficient)	FX
	2 (poor)	F
	1 (very poor)	F

It is no wonder that tutorials are considered by students as the most valuable learning environment and activity (Table 1). This is the case because the interaction between the instructor and student develops the student's ability to solve problems and perform home assignments. The majority of students are certain that tutorials are a major source of acquired knowledge (Table 1: 32%), with the laboratory classes behind. Presumably, this is also the case for *Circuit Theory*.

As shown in Table 2, students' academic performance is rather modest. This can be explained by the lack of motivation for students to study engineering [6]. But students' academic performance in the laboratory was better than their examination results, although the correlation of examination marks and laboratory assessment grades did not meet the researchers' expectations.

In the same way, the effectiveness of laboratory instruction was evaluated for the course *Signals and Systems*. The questionnaire was distributed among third year students who had one semester of experience in the *Signals and Systems Laboratory*. Nineteen students took part in the survey. The results of the survey are presented in Tables 4 and 5.

As shown in Table 4, attendance at the *Signals and Systems Laboratory* was rated the highest, but the laboratory was not so attractive for students compared to the *Electric Circuits Laboratory*. The situation is very much the same with students' academic performance in the laboratory (Table 5). Evidently, a laboratory with modern instrumentation is a good means to motivate students to study engineering.

Table 4: *Signals and Systems*; results of the survey: students' opinions on lectures, tutorials, laboratory and individual study.

	Lectures m±σ	Tutorials m±σ	Laboratory m±σ	Individual study m±σ
Attractiveness of classes	2.47±1.02	2.05±1.02	2.58±1.02	3.00±1.20
Attendance at classes	2.10±0.94	1.47±0.51	1.16±0.22	
The most valuable classes/activities	2.95±1.13	1.74±0.73	1.95±0.97	3.11±1.05
Most effective learning at	3.32±0.89	1.89±0.94	2.21±1.18	2.58±1.02
Acquired knowledge/skills (%) (in total 100%)	21%	32%	23%	25%
Circuit Theory: hours/per week Students' proposal: hours/per week	3 2.55±0.93	1 2.18±0.87	1 2.00±1.34	5 2.73±1.01

Table 5: *Signals and Systems*; results of the survey on students' academic performance.

Student Performance at	Average Grade as m±σ
Examination	6.68±1.77
Laboratory	6.68±1.38
Individual study/project	8.00±1.80

LABORATORY INSTRUCTION AT KAUNAS TECHNICAL COLLEGE

The main objective of the KTC is to increase the effectiveness of engineering education by close cooperation with industry and a practical orientation of the professional courses on offer [7]. Industry needs graduates from colleges; therefore, colleges can expect some support from industry for the modernisation of laboratory equipment. These instruments for hands-on laboratories are not always up-to-date, but are still applicable for laboratory instruction.

Besides that, there are no problems for a college concerning the industrial placement of students. Industrial placement is a good opportunity for a student to work in a real environment with modern instruments. At least this is the case for Kaunas Technical College.

The effectiveness of laboratory instruction was evaluated for the course of *Analog Circuits*. The questionnaire was distributed among second year students after the completion of the course. In all, ten students took part in the survey. The results of the survey are presented in Tables 6 and 7.

Laboratory and tutorial classes are not separated at the College. The distribution of laboratory activities and tutorials depends upon the course type and features. For the *Analog Circuits* course, the majority of the time is devoted to laboratory instruction.

The results of the survey (Table 6) demonstrate that the attractiveness of the laboratory was rated the highest and the most effective learning took place in the laboratory classes. In addition to this, students' academic performance was the highest in the laboratory with respect to examination and individual study assessments, but the grade is unfortunately not high enough to satisfy an instructor.

The problem needs consideration, not only for colleges, but for universities as well. For the

Table 7: Results of the survey: student academic performance. KTC, 2nd year of study.

Student Performance at	Average Grade as m±σ
Examination	6.13±0.83
Laboratory	6.56±1.13
Individual study/project	6.33±1.00

Table 6: *Analog Circuits*. KTC, 2nd year of study.

	Lectures m±σ	Laboratory m±σ	Individual Study m±σ
Attractiveness of classes	2.00±0.87	1.63±0.92	2.44±0.53
Attendance at classes	1.44±0.53	1.56±0.53	
The most valuable classes/activities	1.67±0.71	1.78±0.83	2.56±0.73
Most effective learning at	1.89±0.78	1.44±0.73	2.67±0.50
Acquired knowledge/skills (%) (in total 100%)	39%	38%	23%
Analog Circuits: hours/per week	3	2	1

moment, we as engineering educators can only speculate on this.

CONCLUSIONS

The educational goals of laboratory instruction are fully implemented in various types of hands-on laboratories. Such an opinion still prevails among engineering educators.

The modernised educational laboratory for hands-on experiments provides a challenge to academic staff to develop new and more effective methods of laboratory instruction. The involvement of some clever students in these activities is on the rise. A hands-on laboratory with up-to-date instruments is a means to improve student's motivation to study engineering.

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BIOGRAPHIES

Romanas Vladas Krivickas is a professor of electronics of the Department of Signal Processing at Kaunas University of Technology, Kaunas, Lithuania. He graduated in radioelectronics from Kaunas Polytechnic Institute in 1961 and received his doctorate from Vilnius University in 1967. As a postgraduate fellow, he was at Tokyo University and the Polytechnic University in New York, USA. After graduation, he dedicated himself to an academic career. His research interests are in circuit theory, signals and systems, and digital signal processing. He is the author of two textbooks. Currently, he is in charge of curriculum development in the Faculty of Telecommunications and Electronics at Kaunas University of Technology.

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He has Acknowledgements from the Lithuanian Minister of Science and Education (1998) and the Latvian Minister of Science and Education (2005).

Global J. of Engng. Educ., Vol.11, No.2
Published in Australia

Intercultural Communication Considerations in Engineering Education

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In the current climate of increasing globalisation making intercultural interaction a virtual inevitability, it is important that engineering students gain awareness of intercultural considerations and cultural dimensions, especially in relation to communication. Notably Hofstede has pioneered the study of various cultural components and their impact on interaction. Culture can act as a filter that can colour the message sent so that the message received differs from what was actually sent. An awareness of cultural components will aid in maximising understanding of communication, thereby contributing to positive student, academic, engineer and worker experiences, and enhancing effectiveness.

INTRODUCTION

New communication technologies (such as the Internet, e-mail, cable TV, satellites, etc), the increasing speed and reduced costs of international transport, migration flows and the internationalisation of business have resulted in an ever-increasing number of people – including engineers – engaged in intercultural communication, such as when dealing with foreign professionals or working in a foreign nation. Governments, universities and private industry emphasise that internationalising curricula is not only important to remain competitive in a global world economy, but even indispensable for the world's survival through global cooperation. In addition to linguistic skills, intercultural competence integrates a wide range of human relations skills. Intercultural competence should be considered as a complex process and not just an encounter [1].

Culture is cited here as an aspect of a country or community, not in relation to organisational culture, and is defined here as the social organisation, way of life, attitudes, customs and beliefs held by a particular country or group. White has identified that culture can also be seen as context-specific, as well as a type of ideology (with the associated ethnocentrism) [2].

The personal culture of a receiver of communication acts as a filter through which he/she interprets the message. This filter may colour the message so much so that the message received may not match the message sent. The source of the communication will most often be within the context of the sender. Indeed, culture has been identified as influencing every facet of the communication experience [3]. To achieve accurate, effective and efficient communication, the message actually received is ultimately more important than what the communicator thought was sent.

Intercultural communication skills at both the verbal and non-verbal levels are important components in managing change in an organisation. As such, they are core factors to be considered when organisations are involved in mergers, acquisitions, restructuring or significant strategic changes. These elements are very important given that graduate engineers will become part of organisations that increasingly have to interact and operate globally [4]. Failed intercultural communication can leave business colleagues segregated instead of viewing each other as partners. Value needs to be added in intercultural communication, whether real or perceived, in order to make positive contributions [5].

Riordan has asserted that the impact of a person's lack of intercultural awareness and misunderstanding can be far-reaching and, as such, *developing a good cultural sensibility is not only good business, it is the ethical thing to do* [6]. The pervasive influence of communication skills in engineering study and the workplace internationally make it a necessity across all cultures.

CULTURAL DIMENSIONS

Communication styles are affected by the culture of those engaged in communication. Hofstede, a pioneer and recognised authority in the impact of culture on perception and human interaction, provided a definition of culture as *the collective programming of the mind that distinguishes one group or category of people from another* [7]. Hall commented that *culture controls behavior in deep and persisting ways* [8]. Hofstede and Hofstede further stated that *people's ways of thinking are culturally constrained* and affect their reactions [7].Culture is socialised in individuals and often reinforced in the education process.

Hofstede emphasised that identifiable cultural characteristics should not be confined within assumed regional paradigms of homogeneity, but rather be restricted to the national level; even then, larger and more diverse nations, such as China, Indonesia and Brazil, should ideally be reduced further to provinces and regions [7]. Indeed, culture is more bound by societies than national boundaries, with differences apparent within even smaller nations (such as the Flemish in Belgium), although the national focus of cultural differences can help to facilitate international cooperation [9]. Hofstede elaborated further that culture has the following characteristics:

- It is a collective attribute, not an individual one;
- It is not immediately visible, but rather manifested in individuals;
- It is common to some people, but not all [7].

Hofstede identified several fundamental components that help to define culture as it influences individuals. His work has been supported and expanded by others [10]. His universal parameters aptly describe how such factors influence how communication is facilitated and how well change is received. Thus, adopting different approaches to communication that suit the context, particularly between organisations in different global locations and between people (including engineers) from different cultures, would achieve more accurate understanding of the message being communicated.

The incorrect identification of similarities (when there are actually few, if any), especially values, attitudes and beliefs, can lead to mixed signals and can contribute to ignoring important distinctions [3]. Given the increasing level of globalisation, notably in engineering projects, this is an important consideration in the education of engineering students' communication skills.

Various cultural dimensions impact on communication with many appearing to be somewhat interlinked. The most prominent ones within the engineering context, and hence important for engineering education, are discussed below. Importantly, these dimensions are relative and not absolute so variations can be expected; in effect, Hofstede has presented generalisations but these should not be interpreted as stereotypes. He also stated that *information is more than words: it is words that fit into a cultural framework* [9].

It may be necessary for instructors to allow for *unlearning*, *reprogramming* or the *re-education* of students from other cultural backgrounds to facilitate the type and style of learning required in that unit or curriculum, and should be considered similar for the workplace.

Power Distance

Power distance relates to degree of (in)equality in a culture and the status accorded to individuals regarding wealth, political power, intellect, etc - *the extent to which the less powerful members … within a country expect and accept that power is distributed unequally* [9]. Interestingly, it was found that employees in high power distance cultures, which incorporate traditional and autocratic management functions with centralised power, preferred this style of leadership, while workers from low power distance cultures, in which organisations tend to have flatter hierarchical structures, preferred a consultative approach, ie *the reality one perceives* closely parallels *the reality desired* in this instance [9]. This has clear implications for engineers who work internationally to recognise the local culture's power element when engaging with subordinates or senior managers.

Also of note is that low power distance cultures value greater public information and consultation, and this will spill over into the implementation of new public engineering projects [11]. This has direct implications on engineers who need to communicate and allocate tasks across international borders, possibly even within ethnically diverse work teams. High hierarchical orientation demands senior staff and authority communicate to subordinates and identify tasks, while the participative style requires a discursive process and discussion forums [12]. Key aspects of high and low power distance are listed in Table 1.

National cultures with a high power distance (and greater local acceptance of inequality) include Malaysia, the Philippines, Russia, China and Singapore. Low power distance countries include Austria, Israel

Table 1: Low and high power distance characteristics relevant to the engineering profession [9][11].

Low Power Distance	High Power Distance
Decentralisation of power	Centralisation of power
Greater need for technology	Less need for technology
Reliance on experience and subordinates	Greater reliance on formal rules and bosses
Subordinates expect to be consulted	Subordinates expect instructions
More modern industry and urbanisation	Less modern industry and urbanisation
Higher need for education of the lower class (ie literacy and mass communication)	Less need for education of the lower class
Technological momentum of change	More static society
Less dependence on elders for education	Greater dependence on elders for education
Some teaching is two-way	Teaching is one-way
Greater questioning of authority	Less questioning of authority
More even distribution of wealth	Concentration of wealth
Importance of individual's independence	Little resistance to integration

(differing markedly with neighbouring Arab countries), Denmark, New Zealand and Australia [9]. Of note is that high power distance countries tend to spend more on university education (reinforcing social strata) while low power distance place more funding in secondary schooling [9].

In this sense, education in a low power distance culture is more student-centred and well suited to Problem-Based Learning (PBL) and constructivism. Two-way communication between the student and instructor is a must in such an educational environment and needs to be considered by engineering educators.

Individualism vs. Collectivism

Gudykunst and Kim have affirmed that individualism-collectivism is the prime dimension of cultural variability that can be utilised to explain cross-cultural likenesses and differences in intercultural communication [13]. It relates to the cultural group and not the state [14].

Countries rated high in individualism include the USA, UK, Australia, the Netherlands and Italy while collectivist-oriented nations include Indonesia, China, Thailand, Pakistan and Ecuador [15]. Christopher found that students from Norway (which scored relatively high on the individualism scale) would express their opinions regardless of the situational or cultural context and not be concerned about causing offence, while the inverse was true for their Thai counterparts [16]. Table 2 lists some of the differences between individualist and collectivist cultures.

The sense of individual versus collective personal identity will impact on how people communicate. Organisational changes will affect the way that workers communicate across cultural boundaries. For example, Granered cited the example of a merger between two steel companies – one based in the USA and the other in South Korea. Questions were sought by e-mail before the holding of a videoconference, but almost all the questions were from US workers, thereby adversely influencing the outcomes of the communication exchange and not addressing the concerns of one side; the USA ranks highest on the individual scale compared to the collective orientation of South Koreans [4]. Change can be more effectively managed by focusing on the culture inherent in the society, so for those with individual orientation, individual efforts should be recognised and communication sought from

Table 2: Individualist and collectivist cultural characteristics relevant to the engineering profession [11][14].

Individualist Focus	Collectivist Focus
More modern industry and urbanisation	Less modern industry and urbanisation
More economic development	Less economic development
Education pragmatic and for the majority	Education traditional and for the minority
Education is a permanent process	Education more for the young
Learn how to learn	Learn how to do
Task prevails over relationship	Relationship prevails over task
Tradition of individualist thinking and action	Tradition of collectivist thinking and action
Larger and universalistic organisations	Smaller and particularistic organisations

people on a personal basis (appealing to their self-interest), while communicating change in collectivist cultures should focus on group benefits and encourage group work [12].

Interestingly, Hofstede noted that the most cited psychologists were Americans compared to the heavy emphasis on European sociologists and that this has parallels with the overtly strong individualist culture of the USA versus that of the more collectivist-oriented Europe [7]. This has direct implications on national and/or regional education and research development, as well as students' understanding and perceptions of validity and national academic strengths, while also indicating a self-reinforcing cycle of this cultural axis within a national education curriculum that inhibits international exchange. The increasing prominence of Asia should facilitate a greater diversity of academic thought and research, thereby overcoming ethnocentric research directions and foci by exchanging ideas with international colleagues.

Uncertainty Avoidance

Uncertainty avoidance relates to how well cultures handle uncertainty, avoid ambiguity and engage in risky behaviour. However, uncertainty avoidance often involves risk-taking to reduce ambiguity [9]. The level of anxiety also reflects on tension that workers usually encounter in the workplace. Also, *anxious cultures tend to be expressive cultures* in that *people talk with their hands, where it is socially acceptable to raise one's voice, to show one's emotions, to pound the table* [9]. It has also been found that people from high uncertainty avoidance cultures tended to take embarrassment more seriously with increasing hostility between parties to save face by overtly communicating aggression [17].

Hofstede identified China as scoring weak in uncertainty avoidance, but Japan was ranked highly [7]. Awareness of these characteristics will aid intercultural engineering communicators to more effectively interact with each other and not be distracted by cultural idiosyncrasies. Structure-focused and risk-oriented cultures will thus require somewhat different methods of communication, particularly within an organisation. Structured cultures, such as Greece, Portugal, Uruguay, Poland or Japan, would require more concrete information and established procedures (preferably documented) with clear-cut objectives than for those in more risk-oriented cultures like Singapore, China, Vietnam, India or Sweden [4][15]. Precise instructions and detailed job descriptions are important in ambiguity averse cultures; this has clear implications for engineering communication, particularly technical communication. The recognition of rituals in business and interpersonal communication, plus the use of formal communication channels, is another aspect that must be considered by engineers engaged in intercultural communication; hence, it must also be considered in engineering education to maintain relevance for graduate placements in industry. Interestingly, people in low uncertainty avoidance cultures may more easily acquire cross-cultural sensitivity [11]. Tables 3 and 4 show identify the prime differences in uncertainty avoidance within the contexts of education and the workplace, respectively.

Gender Dimensions

Hofstede and Hofstede also divided cultural aspects between so-called *masculine* and *feminine* traits. They did not mean for this to be definitive genetically of male/female differences but based more on traditional and socialised perspectives of gender roles [9]. There was no significant correlation of the gender dimension with power distance, individualism or uncertainty avoidance [11]. Interestingly, men in feminine work roles had more feminine values than women held in masculine roles. Of further note is that an IBM study found sales representatives (competition), and engineers and scientists (technical focus) were the two highest masculine occupations of six job types at IBM [9].

Table 3: Key differences between low and high uncertainty avoidance in education [11].

Low Uncertainty Avoidance	High Uncertainty Avoidance
Students expect open-ended learning situations and wide discussions	Students expect structured learning situations and seek the right answers
Teacher does not need to have all the answers	Teachers should have all the answers
Students learn that truth is relative	Students learn that truth is absolute
Students attribute their achievements to their own personal abilities	Students associate their achievements to effort, context and luck
Female students' independence important	Females have traditional roles
Students hope for success	Students fear failure
Preference for tasks with uncertain outcomes, calculated risks and problem-solving	Preference for tasks with certain outcomes, no risks and instructions to be followed

Table 4: Key differences between low and high uncertainty avoidance at work [9][11].

Low Uncertainty Avoidance	High Uncertainty Avoidance
Weak work loyalty; short duration of employment	Strong work loyalty; long duration of employment
Preference for smaller organisations	Preference for larger organisations
Scepticism towards technological solutions	Strong appeal of technological solutions
Innovators feel independent of rules	Innovators feel restrained by rules
Top managers involved in strategy formulation	Top managers involved in operations
Boss' power dependent on position and relationships	Boss' power dependent on control of uncertainties
Low stress and low anxiety	High stress and high anxiety
Tolerance of ambiguities in procedures/structures	Highly formalised concept of management
Transformational leadership role valued	Hierarchical control role valued
Better at invention, worse in implementation	Better at implementation, worse in invention
Precision and punctuality to be learned and managed	Precision and punctuality come naturally
Relationship orientation	Task orientation
Lack of appeal of flexible working hours	Flexible working hours popular
Focus on generalists and common sense	Focus on specialists and expertise

Table 5 lists various aspects of feminine and masculine traits.

Assertiveness and ambition are considered by Granered as *masculine* traits and so are regarded differently in various cultures; eg assertiveness is more respected in the USA but perceived negatively in Norway [4]. This also affects the communication process with regard to conflict resolution; the feminine cultural preference towards compromise contrasts to the masculine domineering and forceful approach. Likewise, this impacts on learning styles and education – including engineering education. Further, masculine cultures display greater competition among students for best grades while feminine cultures seek pass grades or at least modesty in study excellence; this is also reflected in how graduates sell themselves in job interviews in that masculine culture workers focus on perceived career opportunities over actual interest in the profession [9].

It follows then that engineers from masculine cultures will tend to be more competitive and seek career opportunities, recognition and rewards compared to feminine cultures where engineers would generally have a more intrinsic interest in the subject and seek a work-life balance but also communicate in a more abstract manner. High masculine trait countries include

Table 5: Feminine and masculine traits relevant to the engineering profession [9][11][14].

Feminine Cultural Characteristics	Masculine Cultural Characteristics
Cooperation at work	Importance of challenge and recognition
Assertiveness ridiculed	Assertiveness appreciated
Job security important	Advancement and earnings important
Values between men and women very similar	Values between men and women differ greatly
Lower job stress	Higher job stress
Group decisions rated highly	Individual decisions rated highly
Excel in manufacturing to customer specifications	Excel in manufacturing in large volumes
Private life protected from employer	Employer may invade workers' private lives
Promotion by merit	Promotion by protection
Work not considered central in daily life	Work considered very central in daily life
Rational self: empathy with others	Ego self
Ambition, daring and independence valued less	Ambition, daring and independence valued highly
Intuition valued highly	Decisiveness valued highly
Achievements by quality contacts and environment	Achievements by ego boosting, wealth and recognition
Greater benevolence and modesty	Greater need for recognition and self-assertion
Managers' goals focus on service	Managers' goals focus on leadership and self-realisation
More female managers and smaller gender wage gap	Fewer female managers and higher gender wage gap
Managers expected to seek consensus, use intuition and deal with feelings	Managers expected to be firm, decisive, assertive, aggressive and competitive
Higher norms of emotional stability and ego control	Lower norms of emotional stability and ego control
Conflict resolution through negotiation and compromise	Conflict resolution through denial and fighting
Integration of immigrants favoured	Assimilation of immigrants favoured

Australia, Japan, China and Poland, while high feminine trait nations include Norway, Denmark, Thailand and Russia [9][15].

There should be no value judgement made between the poles of this scale; nevertheless, the masculine trait of seeking to resolve disputes through denial, blame allocation and fighting may lead to an escalation of aggression and dissatisfaction in the workplace and study environment, as well as seeking opportunities for reprisal action that can obscure, delay or halt the achievement of *outcomes*. As such, this is a serious consideration for students and working engineers who need to be careful as to how they communicate with people from other cultures. Moreover, the feminine trait of fairer distribution would be better for longer-term global survival [9].

Long-Term vs. Short-Term Orientation

A long-term cultural orientation is aimed at future rewards including perseverance and thrift, while a short-term focus targets the fulfilment of social obligations and *virtues related to the past and present* [9]. Short-term orientation also emphasises punctuality and less time for the communication of results; for students, this includes receiving academic results [16]. Industry in long-term cultures tend to focus on building up market share over short-term results, and deplore hastily adopting or abandoning new or novel ideas [9]. When communicating in long-term cultures, the focus should be on long-term results, the development of lifelong networks and work relationships and less strong on tradition.

Hofstede identified the main long-term nations to be many East Asian countries, notably China, Taiwan, Japan and Vietnam, plus India and Brazil (although intracultural clusters need to be considered with the latter two), while prominent short-term cultures were Nigeria, Pakistan, Spain, the UK, USA and Philippines. Of note is that countries with more fundamentalist ideologies were also short-term, tending to focus on the past for guidance than the future, indicating how radical political, nationalist and extremist religious perspectives influence the cultures of their respective groups plus the perspectives and perceptions of their constituents [7]. Hofstede also noted that the Asian tendency towards affluence may move these cultures closer to short-term orientations although declining world resources may promote frugality and long-term vision over consumption and immediate gratification [11]. Further, Asians and Nordic Europeans viewed globalisation as westernisation and Americanisation, respectively, potentially due to its apparent short-term nature and lack of a common future vision for humankind [9]. Table 6 identifies various components concerning short-term and long-term orientations.

Ethnocentrism and Cultural Bias

Ethnocentrism relates to the extent to which a person sees his/her race or nation as being at the centre of the world and directly impacts on their perception of the self and one's affiliated nation. At an extreme, it could be seen to include the distortions of egocentrism and destructive nationalism, with the high uncertainty avoidance dimension also contributing to racism and other bigotry [9].

Stereotyping can affect communication as well. If engineering students are not taught to break out from stereotyping people and other cultural groups, then they could be denied work, education and social opportunities. The problem of stereotyping extends also to educators having predefined views of notably international students [18].

However, the term *ethnocentrism*, while encompassing culture-centric bias in Hofstede's studies, nevertheless suggests a focus on ethnic/racial characteristics, so *cultural bias* may potentially be more accurate. Other bias that affect a person's perception and capabilities in communication include his/her culture's view of such inherent human characteristics as gender, race, age and sexuality, and social constructs like class, religious affiliation, gender roles, etc, plus associated aspects such as literacy rates.

Table 6: Characteristics of long-term and short-term orientations relevant to engineering [9][11].

Short-Term Orientation	Long-Term Orientation
Expectation of quick results	Persistence and perseverance
Relationships not ordered by status	Relationships ordered and observed by status
Personal stability	Personal adaptability
Fuzzy problem-solving	Structured problem-solving
Talent for theoretical and abstract sciences	Talent for applied and concrete sciences
Tolerance and respect valued	Thrift valued
Analytic thinking	Synthetic thinking
Student success attributed to luck	Student success attributed to effort
Differentiation according to abilities	Collectivist and roughly equal social conditions

Similarly, a certain dominant cultural aspect, such as religion or nationality, will alter a person's unconscious perceptions of others [19]. Given the pluralistic nature of an increasingly interconnected global society, cultural bias can be seen as a filter that can alter the perceived meaning of what is being communicated by both the sender and receiver. Reducing cultural bias means recognising that differences exist.

Christopher found that Thai and Norwegian students preferred working with those of the same cultural background as it was easier for them to communicate with each other [16]. Overcoming this cultural bias and extending students' communication skills can be achieved by ensuring that students from national backgrounds interact with each other, notably on group assignments; this has an implication that the instructor will need to maintain stronger control over students' allocation in assigned tasks, be it in class or out-of-class assignments. Similarly, a more effective and adaptable engineering workplace can be attained if there is greater cultural diversity among workers.

Intercultural communication also entails an understanding of different cultures. Fostering education in this area, especially for engineering students, may be best targeted at those cultures that students, as future graduate engineers in a globalised working environment, are likely to encounter or select. Moreover, professionals engaged in intercultural communication will need to learn how to express, compare and relate their own cultures to other people, including within the regional context [20]. The associated high costs associated with the use of people/units that can act as liaisons between cultures in international engineering projects may mean that it is more feasible for individual engineers and managers to be trained to recognise and acquire intercultural skills.

Context of Communication

Hall separated cultures depending on their method of communication, dividing them into either *high context* (such as Thailand) or *low context* (such as Norway). High-context communication (usually found in traditional cultures) is characterised whereby *most of the information is either in the physical context or internalized in the person, while very little is in the coded, explicit, transmitted part of the message* [21]. Conversely, low-context communication (usually found in modern cultures) is the opposite in that the information communicated is made explicit.

It was noted that the high/low context of a person's culture influences his/her perceptions of teaching and learning and their respective styles [16]. This clearly has implications beyond acknowledging different communication methodologies but also *how* people learn (and teach) and so is very important when engaging with international engineering students from cultures of different communication contexts; for example high-context cultures *rely less on explanation and logic* [8][16]. Christopher's study noted that students from the high-context Thai culture expressed themselves less, avoided confrontation and stressed group learning with less interactivity in class, while those of low-context Norwegian backgrounds engaged more in direct communication and expressed themselves in a more individualistic manner [16].

INTERCULTURAL AWARENESS

It should be recognised that verbal skills acquisition with regard to language must be accompanied with non-verbal language skills within key cultural context(s) of the language studied. Indeed, learning the non-verbal *signals* of certain cultures will serve to make the individual a more powerful communicator [22]. Intercultural awareness is a particularly pertinent matter when considering non-verbal communication. This includes body posture, movements and gestures, facial expressions, eye contact, touching, interpersonal distance and greetings. Critical incidents have been used to teach cross-cultural sensitivity to university-level students, targeting cross-cultural miscommunications in language classes [23].

High-context cultures rely more on non-verbal cues in communication than do low-context cultures. As such, being able to *read* non-verbal signals is a vital component to achieving understanding between speakers in non-verbal communication. This relates to Hall's concept of the *silent language* [8]. This non-verbal communication component has a major impact on intercultural communication. As we all utilise this subtle and unconscious act of communication and because it is culturally specific, any training in intercultural communication for engineers will necessarily incorporate this factor.

Accents and other aspects of speech like intonations and speed, can affect intercultural communication. Rogerson-Revel found that native English language speakers had to modify their English in international business contexts by using slower and clearer speech, avoiding jargon, metaphors and colloquialisms, repeating ideas in different ways, and relating the message to the other person's culture and situation [24]. Indeed, speaking the same language does not equal speaking the same way [25].

The increasing migration and people exchanges accompanying globalisation is resulting in broader diversity not just in the workplace, but also in the classroom, so it is important that engineering educators are trained to be sensitive to, and proactively manage, intercultural elements in the classroom. This involves knowledge acquisition, recognising different methods in solving problems, communication methods, learning styles and the use of symbols [26]. Effectively managing this can lead to greater study success and thus better future employment opportunities for engineering students.

To minimise distortions in their communication, students (as future engineers) need awareness and a general understanding about cultural differences. Culture general knowledge instruction can be undertaken to cover the following aspects:

- Develop an understanding of bases of cultural differences;
- Understand the influences of culture on communication and associated behaviours;
- Acquire intellectual curiosity, tolerance and empathy towards foreign cultures and their inhabitants;
- Develop an open-minded attitude to others and other cultures [27];
- Recognise that increasing intercultural communication does not parallel sharing common values;
- Engage in active communication when there is misunderstanding (ie seek clarification, undertake personal development tasks to increase vocabulary, etc) [25].

If students are equipped with these basic competences upon graduation, they will be more in a position to acquire specific knowledge and skills in their professional lives. In practice, this could mean that a professional engineer is required to spend time in a particular country as a project manager (eg at a construction site). With this basic understanding of awareness and general cultural knowledge provided at the university level, the future engineer should be more efficient during initial interactions with people from a foreign culture.

Intercultural student exchanges are one method that can help students learn about the impact of intercultural differences in communication, and differences between the student's native culture and the host one. Indeed, cultural diversity entails greater cultural interaction. However, the popularity of intercultural student exchanges is influenced by international credit transfer systems. In this respect, the well-documented European Credit Transfer System (ECTS) facilitates greater student and professional mobility in the region by recognising and incorporating equivalence in study programmes. Intercultural exchanges also require organisational support (eg at the university, governmental and regional (like the EU) levels), such as scholarships.

Finns generally have a negative view of immigrants and this was reflected in Finnish students placing a low emphasis on learning intercultural communication skills, indicating how cultural dimensions reverberate across the support provided by educational and organisational structures, including lacking engineering student exchange programmes [28].

While individuals do not always act according to what they say, they do tend to behave in line with their cultural mental models. This has direct ramifications for students with regard to their education and how they respond to new work environments. Reflection skills can aid engineering students in countering the adverse impact of incorrect mental models, and making them more proactive in mastering their personal mental models of the world around them. Communication skills can help in mastering mental models and a loop-like situation develops, wherein improving communication skills helps students to master their mental models, which in turn amplifies communication skills. For example, Senge's suggested guidelines in countering the adverse impact of mental models, in inquiring about another's viewpoint while also advocating one's own viewpoint, necessitates a good level of verbal communication skills [29]. A lack of awareness of personal mental models means that they go unexamined and hence, do not change; mental models *impede* learning, just as they can *accelerate* learning [29]. Notably, mental models can act as a filter used by people when engaged in communication, both sending and receiving.

Although targeting translators, Nord identified various aspects important for effective intercultural communication [30]. Several of these can be applied to the skills required for communicating interculturally, including for engineering students and graduates. Key aspects include:

- Verbal and non-verbal components are guided by situational and cultural factors, and applies to both source and target-cultural communication;
- Skills to actively identify points of communication conflict/breakdown due to divergent cultural backgrounds and find ways and means to neutrally overcome them;
- Culture-specific non-verbal communication components can interfere with functional communication, even when the language structure is the same [30].

CONCLUSIONS

Technical skills alone are no longer sufficient in this brave new world of advancing engineering education and globalisation; intercultural awareness is a prime component that will facilitate the adaptation of future engineering graduates. By providing the right curricula contents, universities should seize the opportunity to contribute in shaping the required modern engineer at the start of the new millennium, evolving understanding and contributing to global understanding for the next generations of engineers.

Culture is evidently not a static concept but influenced by many factors over time. The direct influence of the multifaceted aspects of culture on communication has direct implications for engineering education and industry. With regard to curriculum, it may mean that course and curriculum structures need to be adjusted and modified to take into account cultural differences between students; how they learn and how they are taught. This may require additional training and skills of educators; as such, these elements should be considered as important components for the life-long learning of engineers and engineering educators.

Multidimensional cultural labels provide a guide for engineers and engineering educators when engaged in international activities or when dealing with colleagues (such as fellow engineers and/or academics) from other cultures. However, care must be given that these dimensions offer recognition of other cultural norms and values and so stereotyping all members of a foreign culture with singular traits can lead to errors and miscommunication. One method to advance intercultural understanding (and with that intercultural communication) is facilitating opportunities and environments where people from different cultures can meet and mix as equals, including at universities and workplaces.

Awareness of cultural differences can also contribute to engineering students' and academics' reflection skills in that they can identify their own style, but also start to understand alternative perspectives and their validity.

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BIOGRAPHY

Marc Jorrit Riemer completed a Bachelor of Arts in 1989 at Chisholm Institute of Technology, Melbourne, Australia, and finished his Honours year in English at Monash University in Melbourne in 1990. He later completed a Bachelor of Business (Business Administration) in 1995, also at Monash University. His hobbies include reading, science fiction and learning html, and he undertakes volunteer work for an immigration support group.

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