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Dr Dermot Brabazon & Dr Abdul Olabi
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Dermot Brabazon & Abdul Ghani Olabi

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Preface

The International Symposium for Engineering Education, ISEE-08 provides a forum in the field of engineering education to share best practice and resources. This includes those delivering science, mathematics and other related teaching to engineering students. Exciting new tools for the educator to meet the ever evolving needs of the students will be presented and discussed at this symposium. These include usage of Virtual Learning Environments and Virtual Instrument (VI) simulations which are becoming more commonplace in the learning environment. These proceedings are presented in six separate sections corresponding to the six sections in the conference which are Bologna and Engineering Program Structures; Future of Engineering Education; Student Teaching and Assessment Methods; Soft skills: communication, ethics and entrepreneurship; Project, Laboratory, and Problem Based Learning; and IT in Engineering Education

In this conference 37 papers were accepted from international delegates covering wide ranging areas concerning Engineering Education. This conference provides a forum for senior as well as young academics who are actively engaged with Engineering Education research to come together and share their experiences of advances made in these areas.

We would like to thank Prof. M.S.J.Hashmi for his unlimited support and advice. We would like to thank the conference co-ordinators Ms Muireann O’Keeffe and Dr Sumsun Naher for there great help with various tasks at crucial stages of organising this conference. Many thanks go to the members of the International Advisory Committee who reviewed and refereed the papers for the conference proceedings.

Finally, sincere thanks must go to authors of the papers. Without timely submission of the manuscripts of high quality, publication of these proceedings would not have possible.

Dermot Brabazon & Abdul Olabi
Editors  September 2008
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Bologna and Engineering Program Structures
ABSTRACT
The Bologna process started in 1988 to celebrate the 900th anniversary of the University of Bologna. It was adopted as a political instrument by some EU Nation States in 1998 when there was considerable concern over the economically unsustainable, grossly inefficient higher education systems in Europe. The Bologna process of three cycles of Higher Education has received widespread agreement across now 48 nation states. For certain sections of UK higher education, such as engineering and science, where the traditional degree do not fit with the Bologna cycles, the Bologna process presents significant difficulties. This paper explores those difficulties, and possible responses, none of which are without difficulty.

Keywords Bologna process, UK Higher Education, Engineering Degrees.

INTRODUCTION
The views expressed here are solely those of the author, although there are a number of members of the EPC who share similar concerns. The EPC’s interest in Bologna goes back approximately four years, when it was obvious to EPC members that dramatic changes were afoot in Europe, but there appeared to be little or no engagement with the process from the UK. After much talking, as will be illustrated below, little has changed in the intervening period.

The Bologna process
The background to the Bologna process is that there was considerable concern in the 1990s at governmental level in the EU that Italy, Germany, France and many New Accession States have economically unsustainable, grossly inefficient higher education systems. Also, that the European higher education system was not making a sufficient contribution to the wealth creation process in the EU, and that the EU higher education system was hidebound and resistant to change. A potted history of the Bologna story so far is as follows.

The Bologna process began in 1988, with the publication of the ‘Magna Charta Universitatum’ which originated at the University of Bologna to celebrate the 900th anniversary of that university, the oldest in Europe [1]. The charter simply called for an open, transparent, European HE system. Following the publication of the charter, there were various key stages to the process, which were:
1998 The Sorbonne Declaration. This covered the harmonisation of European Higher Education, and was signed by France, Italy, Germany and the UK [2].

1999 The Bologna Declaration. Most people think this was the start of the process because at that time the Declaration was signed by 29 nation states [3].

2001 The Prague Declaration. This reaffirmed Bologna, and the Commission ‘appreciated’ role of the European Universities Association, which is the association of Rectors of European Universities (in the UK the equivalent body is Universities UK, known as UUK) [4].

2003 The Berlin Communiqué. This included the role of quality assurance in the Bologna process. It officially adopted the two-cycle degree process, and included the recognition of degrees and periods of study as defined by the European Credit Transfer System (ECTS) [5].

2005 The Bergen Declaration. This reaffirmed Berlin, and added a third cycle of degrees which are exclusively PhDs. It did not embrace EngD’s etc, known as the ‘professional doctorates’. In Europe there are no equivalents of the UK’s ‘professional doctorates’, and their place in the Bologna process is still undecided. Bergen also included the notion of the ‘Integration of the European Higher Education Area and the European Research Area’, and posited the Bologna Process as the ‘instrument to achieve the integration of the EHEA and the ERA’ [6].

2005 The Glasgow Declaration. This was largely concerned with ‘refocusing the Bologna process midway to 2010’. Its banner headline was ‘Strong universities for a stronger Europe’, based on ‘the knowledge society through higher education and research’. The manipulation of the Bologna process was thus to enhance research and innovation within Europe [7].

2007 London Communiqué. The UK held the presidency, Communiqué contained the statement by Bill Rammell (Minister for Higher Education): engage with Bologna follow Imperial’s lead” [8].

2009 The “final”? Bologna conference will be hosted by the BENELUX states [9].

The Bologna process is not a European Union programme, membership is much wider than the EU, and the EU has only partial ‘competence’ (constitutional power) over education matters. As has been pointed out on a number of occasions recently there is no over-arching Bologna Directorate (as yet?) [10], and so it is a matter of being compatible with Bologna, not Bologna compliant. However, the EU is a principal stakeholder in the Bologna process, which is a commitment by 45 countries across Europe1 to harmonise their systems and structures of higher education in order to create an integrated European higher education area (EHEA). ‘Bologna’ has now taken on an ever more important international role, as China, Latin America, Australia and Asian countries are now officially designated as ‘Bologna Observers’ and attend all meetings [11].

1 Albania, Andorra, Armenia, Austria, Azerbaijan, Belgium, Bosnia-Herzegovina, Bulgaria, Croatia, Cyprus, Czech Republic, Denmark, Estonia, Finland, France, Georgia, Germany, Greece, Holy See, Hungary, Iceland, Ireland, Italy, Latvia, Liechtenstein, Lithuania, Luxembourg, Malta, Moldova, Netherlands, Norway, Poland, Portugal, Romania, Russian Federation, Serbia-Montenegro, Slovak Republic, Slovenia, Spain, Sweden, Swiss Confederation, Turkey, Ukraine, United Kingdom, the former Yugoslav Republic of Macedonia. (European Union countries in bold).
The three educational cycles

The Bologna principles are, on the face of it, quite straightforward. The devil is in the detail. Bologna calls for a transparent EU-wide system of degrees and definitions permitting wide exchange and collaboration of nation states, in three cycles:

- The first cycle ‘Mobility degree’, comprising 180 ECTS, which on a time-served basis can be equated (maybe) to 3 years, and is equivalent to the UK’s Bachelor’s degree. Entry to the first cycle is based on national criteria.
- The second cycle degree, the Master’s level, which is awarded after the achievement of 90-120 ECTS, i.e. 1.5 to 2 years of full-time study, with an absolute minimum of 60 ECTS, or one year. Entry to the second cycle is on completion of the Bologna first cycle.
- The third cycle, or Doctoral level degree, which is as yet undefined in terms of either timescale or ECTS. The EUA meeting at Salzburg in 2005 [13] could not agree on either a timescale, although 3-4 years was generally discussed, or the number (or even if) ECTS should be used in the context of a third cycle degree, although some nation states already have this. Entry to the third cycle is on completion of the Bologna second cycle.

The difficulties with this process are encompassed in the statements in italics above; ECTS being the principle stumbling block. As the entry to first cycle degrees is on the basis of national criteria, then this is no problem. However, as entry to the second and third cycle degrees is by completion of the previous Bologna cycle, then if a national qualification is not recognised as Bologna compatible, as may happen to the [EWNI] qualifications of MEng, MMath, MPhys and MChem, then candidates with these qualifications may find it difficult to gain admission to postgraduate degrees in European countries; UUK has evidence that this is already happening. Problem areas for the UK:

ECTS: The fundamental problem with the Bologna Process for the UK, and most other Nation States, is the thorny problem of compatibility with the European Credit Transfer System (ECTS). ECTS on the face of it seems fairly straightforward: 60 credits = one full academic year. But does this mean 30 weeks or 46 weeks? There used to be a statement in the EUA Bologna Handbook that there is a maximum of 75 ECTS available in a calendar year, this has apparently now been removed. ECTS was/is a largely a ‘time served’ measure, which jars with a learning outcomes-based approach, as has been championed by the UK; and particularly by the EPC [14]. In some European countries ECTS has become enshrined within and defined by law. For example, in some parts of Germany, it is based upon an academic year of 1600 hours, being 40 weeks at 40 hours per week; therefore, 1 ECTS = 26.7 SLHs; some German other Universities stipulate 1800 SLHs Using this approach, there is a variety of interpretations of ECTS across Europe and figures ranging from 26.7 SLHs in Germany to 15 SLHs in Bulgaria can be obtained. To preserve our competitive position, we need to take care that comparisons are being properly made with the right overseas Institutions.

One of the fundamental stumbling blocks to compatibility with ECTS for England, Wales and Northern Ireland (EWNI), is that we do not actually have an agreed national credit system; most Universities use a fairly standard model, but not all. At the present time the Burgess Group [15] will apparently produce recommendations this year that EWNI adopt a model of 120 CATS (Credit Accumulation and Transfer System) credits per academic year (30 weeks), which gives 1 credit equals 10 SLHs, and means an 20 SLHs per ECTS. For postgraduate degrees the total will be 180
CATS per year. This will give automatic ECTS comparability problems, and a minority opinion in England is that we should go for a straight ECTS system, as apparently championed by Bill Rammell in his evidence to the Select Committee on Higher Education when he stated that “ECTS is the only game in town”[16]. It is understood that through the Qualifications and Curriculum Authority (QCA) that ENWI will then self-certify to Bologna in late 2008.

There is a significant body of opinion within the Bologna signatories that learning outcomes need to be linked to standards, perhaps also with a time measure; ECTS’s are being regarded in certain areas as becoming a ‘volume’ measure of learning outcomes. This is changing, and there is hope that changing to output standards and ‘levels’ can be accomplished by linking to the Dublin Descriptors, which are levels of attainment after first, second and third cycles [17].

The MEng etc: MEng degrees are now called ‘integrated four year’ Masters degrees’. They were initially called ‘undergraduate Masters’ to obtain HEFCE (UK government) funding. These degrees are clearly not 3+2 and so, on the face of it, do not qualify as Bologna second cycle degrees.

If the MEng degree is compared to European degrees on the basis of 2CATS to 1ECTS it appears to be worth 480 CATS ~ 240 ECTS and this is just below the limit (270 ECTS) proposed under Bologna. However, in reality we are comparing 4x1200 = 4800 SLHs on the UK system with 5x1600 = 8000 SLHs on most European systems. This is the major difficulty, our European colleagues simply cannot understand how we can reach the same educational standard as them with this difference of SLHs, regardless of how learning outcomes are used.

Some nations eg France, Germany, Italy and Spain, in moving from 5-year degrees to 3+2 degrees have deep concerns as to what is the use of the first cycle degree. The 3-year PhD is also an anathema to many in EU countries where PhDs commonly take nine years to complete. It is also significant that a some of the premier US universities are not accepting Bologna first cycle degrees as suitable for entry to PhD study.

In the UK engineering qualifications are accredited under the EC UK-SPEC, which is explicitly Bologna compatible. The definitions are (author’s italics):

Chartered Engineer – an accredited Bachelors degree with honours in engineering or technology, plus either an appropriate Masters degree accredited or approved by a professional engineering institution, or appropriate further learning to Masters level or an accredited integrated MEng degree.

Hence UK-SPEC [18] is inherently Bologna compatible, it’s the ‘or’ where we may get into trouble!

Alternative strategies: A strategy being explored in some higher education institutions in the UK is that of bolstering the MEng by adding in extra credits. For example, an extra 30 credits between levels 3 and 4, in the shape of a credit-bearing industrial placement, gives 90 credits i.e. the minimum for the award. Another strategy is to bolt on a further 30 credits beyond the fourth year as an extended project, or a credit-bearing industrial placement. These are both in-line with the Leitch agenda [19]. However, the latter can be a clumsy solution, as for most Universities it delays the award of the degree. There are also fee and student debt implications for all of these strategies, which as yet do not appear to have been thought through.
The Imperial College model has been referred to on a number of occasions, again without considering important detail. Imperial College has been actively considering its position under Bologna for around 5 years. Following detailed surveys they have determined that their student working week is 47.5 hours (under the Post-Burgess group it is likely to be described as 40 hours per week), which gives an academic year of $47.5 \times 30 = 1425$ SLHs per year or $23.75$ SLHs per ECTS. They find the extra 30 ECTS to bring the total to the 270 ECTS limit used in Bologna, by giving ECTS for work based learning or other activities. Imperial College have already made the point on a number of occasions that not every University in the UK will be able to justify following this model.

It is also perhaps worth noting at this stage that although many educational institutions in Scotland seem to believe that they are Bologna compatible with their five-year MEng, this is in fact not strictly true, as the Scottish BEng is a four-year degree, although it is supported by the SEFI (the European Society for Engineering Education). A further similar suggested work-around for the rest of the UK, by rebadging our Level 0 (Foundation Level) as the start of our degree programmes, and admitting ‘A’ Level students at the second level, falls at the same hurdle, as the BEng is then a four-year degree, and so BEng and MEng still do not add up to a 3+2.

A further reason why we need to be very careful with all these alternative strategies is that any admission of inequality between MEng degrees could have serious repercussions for international accreditation agreements. It could also have knock-on effects in FEANI (European Federation of National Engineering Associations) [20] and the members of the Washington Accord [21]. The UK is already under pressure with FEANI, as evidenced by the recent attempts to have UK degrees removed from the register.

In 2001 the American Society of Civil Engineers produced a report, which made the case of a 5 year Masters degree as the exemplar for a Professional Civil Engineer in the US [22]. Engineers Ireland in a report in 2003 also recommended a five year Bologna compatible Masters degree to maintain the international competitiveness of their engineers [23].

In 2005 The US National Academy of Engineering report “the Engineer of 2020” also concluded that the 4 year bachelors degree should be regarded as a preparatory degree for engineering [24].

The whole problem of ECTS for EWNI is one which the Higher Education Europe Unit has been given the task of resolving. However, there are extremely difficult issues to be resolved at the detailed level. There is also growing external competition, particularly in regard to the one year Masters programmes from Europe, which are offering competitive programmes at much cheaper rates. Higher Education Institutions in the UK need to keep a close watch on the Bologna process. It is likely that the UK will win the battle over credits and learning outcomes but equally it is likely that we will lose the war over credits and ECTS. In the medium term we need to consider the whole structure of UK engineering degree programmes to retain international competitiveness.
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TRANSITION FROM 4-YEAR TO 5-YEAR MASTER’S-LEVEL PROFESSIONAL ENGINEERING EDUCATION IN IRELAND

David Timoney and Brian Mulkeen

School of Electrical, Electronic and Mechanical Engineering, University College Dublin, Ireland.
E-mail: david.timoney@ucd.ie

ABSTRACT
Initiatives taken recently by Engineers Ireland (formerly known as The Institution of Engineers of Ireland) are triggering major changes in the structure of professional engineering education in Ireland. The long-established 4-year Bachelors degrees are to be superseded by 5-year Master’s-level qualifications, for those wishing to enjoy full international recognition of their qualifications and to attain the minimum educational standard necessary to become Chartered Engineers. These changes have been brought about by trends in Europe and elsewhere but the process of transition is proving to be less than completely straightforward. This paper presents some of the issues arising, particularly from the viewpoint of the educational institutions involved.

INTRODUCTION
Through the Institution of Civil Engineers of Ireland (Charter Amendment Act, 1969), Engineers Ireland aims to set up and maintain proper standards of professional and general education and training for admission to Membership and, in fulfilment of this purpose, has formally accredited engineering degree programmes in the Republic of Ireland since 1982.

The Council of Engineers Ireland is empowered to define and protect the use of the title Chartered Engineer and Chartered members of the Institution of Engineers of Ireland have the right to use after their names the abbreviation “CEng”.

Becoming a Chartered Engineer in Ireland involves;
1. Completion of a degree programme which is accredited by Engineers Ireland,
2. Gaining a minimum of four years postgraduate training and engineering experience,
3. Submitting a formal Engineering Practice Report, supported by two Chartered Engineers familiar with all or part of the applicant’s work, and
4. Succeeding in the professional review process by demonstrating the required competences.

Irish engineering degree programmes are subject to formal accreditation inspection by Engineers Ireland every 5 years.
INTERNATIONAL RECOGNITION OF IRISH ENGINEERING QUALIFICATIONS

Engineers Ireland is a member of FEANI (The European Federation of National Engineering Associations), an organisation which publishes an Index of Approved Engineering Schools and Courses [1] in its 25 European member countries. All engineering degree programmes accredited by Engineers Ireland and satisfying the education standard for the title of Chartered Engineer are listed in the Index and accepted in the member countries of FEANI. Also, Engineers Ireland is a signatory to the “Washington Accord” under which engineering degree programmes accredited by Engineers Ireland are accepted for membership purposes, by the Accord signatories, on the same basis as their own accredited engineering degree programmes. The signatories to the Washington Accord are:

- Engineers Ireland
- The Institution of Engineers of Australia (IEAust)
- The Canadian Council of Professional Engineers (CCPE)
- The Institution of Professional Engineers of New Zealand (IPENZ)
- The Engineering Council of the United Kingdom (EC)
- The Accreditation Board for Engineering and Technology, United States of America (ABET)
- The Engineering Council of South Africa (ECSA)
- The Hong Kong Institution of Engineers (HKIE)
- Japan Accreditation Board for Engineering Education (JABEE)

In a wider context, The Bologna Process aims to create a European Higher Education Area by 2010, in which students can choose from a wide and transparent range of high quality courses and benefit from smooth recognition procedures. The Bologna Declaration of June 1999 put in motion a series of reforms needed to make European Higher Education more compatible and comparable, more competitive and more attractive for Europeans and for students and scholars from other continents. Reform was seen to be needed if Europe is to match the performance of the best performing systems in the world, notably the United States and Asia.

INTERNATIONAL PRESSURES TO MOVE TO 5-YEAR, MASTERS LEVEL ENGINEERING EDUCATION

Engineers Ireland is very active in “ENAEE” (European Network for Accreditation of Engineering Education) [2], which has 14 member organisations. ENAEE was established in February 2006 as a Europe-wide “not for profit international association” under Belgian law. Engineers Ireland was a founding member, together with five other European engineering associations and eight professional associations involved in engineering education.

ENAEE aims “to build confidence in systems of accreditation of engineering degree programmes within Europe and to promote the implementation of accreditation practice for engineering education systems in Europe…in particular…participating in the creation and ultimately the administration of a European accreditation framework for engineering education programmes.”
ENAEE has established what is known as the “EURACE Label Committee”. The six European countries with engineering accreditation agencies constitute the membership of the Label Committee. These are UK, Ireland, France, Germany, Portugal and Russia. These six agencies have been granted, for two years, the authority to award the EURACE First-cycle label to their accredited Bachelor degrees and the EURACE Second-cycle label to their accredited Master degrees, in the context of the Bologna Declaration.

A special concession has been made to Engineers Ireland as we do not yet have the Master degree as our CEng education standard. The EURACE certificates were originally titled EURACE BACHELOR and EURACE MASTER.

In order to accommodate the current 4-year Honours Bachelor Degree as the Engineers Ireland current CEng entry standard, the certificates were re-titled EURACE First-cycle and EURACE Second-cycle. This is a temporary arrangement pending the introduction of the Master degree as Engineers Ireland CEng standard from 2013.

ENAEE has established criteria for accreditation agencies and programme outcomes for first and second cycle degrees to be accredited by authorised agencies. All six agencies are being reviewed and their continued authority to grant EURACE Labels after 2008 is dependent on the outcomes of these reviews.

The net result here is that ENAEE will not authorise Engineers Ireland to grant the EURACE quality label for Second-cycle/Master degrees to any existing 4-year Hons Bachelor degrees beyond 2013.

In the USA the National Council of Examiners for Engineering and Surveying (NCEES) [3] and the National Academy of Engineering are moving to a position where the educational standard for engineering licensure will be modified so that an engineer with a Bachelor degree must have an additional 30 credit-hours (~50 ECTS credits) of acceptable upper-level undergraduate or graduate-level coursework to be considered for licensure. This equates broadly to a Master degree and is due to take effect in the US probably in 2010 but no later than 2015.

Focussing on the American Society of Civil Engineers (ASCE) [4], admission to the practice of civil engineering at the professional level means professional engineering licensure requiring attainment of a Body of Knowledge through appropriate engineering education, experience and examinations. Fulfillment of this Body of Knowledge will typically include a combination of:

- a bachelor’s degree in civil engineering,
- a master's degree, or approximately 30 coordinated graduate or upper level undergraduate technical and/or professional practice credits (~50 ECTS credits) or the equivalent agency/organization/professional society courses providing equal academic quality and rigor, and
• appropriate experience based upon broad technical and professional practice guidelines which provide sufficient flexibility for a wide range of roles in engineering practice.

Current bachelor programs, while constantly undergoing reform, still retain a nominal four-year education process. This length of time limits the ability of these programs to provide a formal education consistent with the increasing demands of the practice of civil engineering at the professional level.

As elsewhere, there are opposing forces trying to fit more content into the bachelor’s degree curriculum while at the same time reducing the credit hours necessary to achieve it. ASCE has concluded that, whilst the civil engineering bachelor’s degree is satisfactory for an entry-level position, it is becoming inadequate for the professional practice of civil engineering. The four-year internship period (engineer-intern) after receipt of the baccalaureate degree cannot make up for the formal educational material i.e. the expanded Body of Knowledge that would be gained from additional formal education.

ASCE envisages that implementation of this expanded Body of Knowledge will not happen overnight and accepts that it cannot mandate that change be completed in a specified time period. ASCE has declared its willingness to be an active partner with other groups and organizations to accomplish this policy, expecting that ultimate full implementation may not occur for 5 to 15 or more years.

The USA-based IEEE (Institute of Electrical and Electronics Engineers) [5] is also considering whether to follow the recommendations of several other professional bodies and declare that a Master of Science or Master of Engineering (rather than Bachelor-level degrees) should be an engineer’s first professional degree.

NEW ACADEMIC CRITERIA FOR CHARTERED ENGINEER STATUS

In light of these important changes on the international landscape, Engineers Ireland planned some important policy changes. In November 2003, Engineers Ireland published a position paper entitled “A New Structure for Engineering Education in Ireland” which proposed that the education of the professional engineer should be through a five-year integrated higher education programme leading to a Master degree, which would satisfy the accreditation criteria of Engineers Ireland. Following consultation with engineering academics in universities and institutes of technology, in July 2006, new Accreditation Criteria for Master degree programmes were published [6].

In May 2007, the Executive Committee of Engineers Ireland decided: “that the education standard for the grade of MIEI and the professional title of Chartered Engineer should be raised to 5-year Master Degree in engineering, awarded on successful completion of a programme accredited by Engineers Ireland, with effect from programmes completed in 2013”.

Students entering 4-year programmes in 2008 and who are successful in completing their programmes in the normal time will graduate in 2012 under the ‘old rules’ whilst all students entering in 2009 or later will be subject to the revised standards.
The new Accreditation Criteria specify programme outcomes in detail. The essential differences between the Master’s programme outcomes and those for the Bachelor degree are (i) the more advanced academic level and (ii) the inclusion of a requirement to be able to carry out research.

**Master’s Level Programme Outcomes**

- Knowledge and understanding of the mathematics, sciences, engineering sciences and technologies underpinning their branch of engineering.
- The ability to **design** components, systems or processes to meet specific needs.
- The ability to identify, formulate, analyse and **solve engineering problems**.
- The ability to **design and conduct experiments** and to **apply a range of standard and specialised research tools and techniques** [replacing the Bachelor’s level outcome: “The ability to design and conduct experiments and to analyse and interpret data;”]
- The ability to **work effectively** as an individual, in teams and in multi-disciplinary settings, together with the capacity to undertake **lifelong learning**
- The ability to **communicate effectively** with the engineering community and with society at large.

**SIGNIFICANT CHANGE OF ENGINEERS IRELAND POLICY: SUMMER 2008**

More recently in Summer 2008, Engineers Ireland Council and Executive Committee have registered concern at some of the implications of the 2007 decision and the Executive Committee has recently decided [7] to;

(a) alter the decision of May 2007 and offer the “MIEI” grade of membership to both Level 8 and Level 9 graduates for an interim 5-year period, and

(b) define and adopt 3 routes to C.Eng. for those graduating with Level 8 degrees after 2013.

To cater for those students who will continue to graduate from level 8 programmes after 2013, three routes which such graduates could follow to enable them to attain Level 9 qualifications are recommended as follows:

- a) Return to university and take the final year of a 5 year accredited engineering programme (Level 9) on a full-time or part-time basis.

or

- b) Take the examinations of the Institution leading to Engineers Ireland Post Graduate Diploma in conjunction with a supervised work-based project.

or

- c) Accumulate 30 ECTS from Level 9 engineering programme modules or Engineers Ireland approved CPD courses either in Ireland or overseas and in addition complete a 30 ECTS credits supervised work-based project, both subject to the approval of the Membership and Qualifications Board.
PROFESSIONAL ENGINEERING DEGREE PROGRAMMES AT UCD

University College Dublin has been working actively to develop and provide engineering degree programmes to meet future needs. The suite of programmes currently offered includes:

- **BE (Hons)**
  - 4 year professional engineering degree {Biosystems, Bioprocess, Chemical, Civil, Electronic, Electrical and Mechanical specialisations}

- **BSc (Structural Engineering with Architecture) leading to Master’s Degree**
  - 3 year bachelors degree {BSc (Hons)}
  - 2-year masters degree in Structural Engineering with Architecture{ME}

- **BSc (Engineering Science) leading to Master’s Degree**
  - 3 year bachelors degree {BSc (Hons)}
  - 2-year masters degree in several specialisations{ME}

![Image of UCD Engineering Degree Programmes (2008 entry)](image)

Figure 1. UCD Engineering Degree Programmes (2008 entry)

**BSc (Engineering Science) Degree**

The BSc degree (launched in 2006) is a modular programme, with 12 modules in each stage (year). As part of the UCD Horizons programme, up to two of these modules can be chosen from outside the engineering science area.

- In Stage 1 (first year) the core modules are common to all students. These include Mathematics, Physics and Chemistry, along with modules in the Engineering Sciences.
- In Stage 2 (second year) students start to specialise by selecting the engineering modules that interest them while continuing some core modules in Mathematics and Engineering Sciences. There is a wide range of modules available, and it is possible to cover more than one area of specialisation.
This process continues in Stage 3 (third year), with most students now concentrating on their chosen area of specialisation. However, there is still scope to take some interesting modules in other areas of engineering.

Figure 2. “3+2” BSc (Engineering Science), leading to ME in several specialisations.

ME Degree

Following the BSc (Engineering Science) degree, students can continue their engineering education and specialise in the Masters of Engineering programme. These ME degree programmes will be modular, providing some flexibility and choice within the area of specialisation. They will include significant project work, with an option for work experience or a semester abroad. In addition to the already existing 2-year ME programme in Structural Engineering with Architecture, 2-Year, 120 Credit ME Degree Programmes are currently being developed in specialisations which include:

- Biomedical Engineering
- Civil and Environmental / Structural Engineering
- Electronic / Computer Engineering
- Energy Systems Engineering
- Mechanical / Materials Engineering
- Engineering with Management

ISSUES ARISING

Resourcing this change from 4-year to 5-year engineering education presents serious challenges to Irish educational institutions, already in some difficulty with student recruitment, facing staff recruitment restrictions and with little prospect of increases in laboratory and teaching space. The prospect of a longer programme may dissuade some students from enrolling in the first place. Others may choose to leave after 4-years with a Bachelor’s qualification which may suffice for membership of Engineers Ireland but which may not enjoy any
international recognition. Whilst some bachelor’s level graduates may eventually return to complete their master’s degrees, the numbers taking the 5th year in the short term may be reduced, yielding dis-economies of scale and threatening the viability of these programmes. It may become necessary for institutions to collaborate in offering suitable advanced-level programmes that meet international standards.

The current ‘Free’ Fees scheme (where EU student tuition fees are paid by the Irish Exchequer) applies only to full-time undergraduate degree programmes. A major disadvantage of the “3+2” structure is that students would be liable for the 4th year fees. As a consequence, it seems inevitable that most programmes will need to be offered on a “4+1” basis for the Irish market. With a view to continued participation in the European Higher Education Area and to facilitate incoming transfers, UCD aims to continue with “4+2” or 120-credit ME programmes but may make arrangements to permit suitably qualified 4-year BE graduates to complete their master’s degrees in one additional year, by offering up to 60-credits for prior learning. The latter might best be described as a “4+(2-1)” arrangement.

CONCLUSIONS
Changes in the minimum educational requirements for entry into a profession such as engineering will inevitably give rise to some difficulties and challenges. Leadership and some courage are needed if the change is to be effected expeditiously. UCD has accepted that international pressures have become overwhelming and has sought to move rapidly towards the provision of 5-year master’s level engineering education as the norm for all. The recent changes in Engineers Ireland policy, aimed apparently at providing for a “no change”, “business as usual” situation have undoubtedly increased significantly the level of difficulty.

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7. Engineers Ireland, Raising the Educational Standard for CEng & MIEI to MEng (MQB Recommendations), Executive Committee Decision July 22nd 2008 - A 04.
ABSTRACT
The main aim of the Bologna Process is to create a common and comparable system of academic standards and quality within Europe. Twenty-nine countries agreed to sign the declaration in 1999 and that number has since increased to forty-six [1, 2]. Attempts have been made by Engineers Ireland to help this process come into affect by the decision to raise minimum requirement of new ordinary members to Masters Degree in Engineering accredited by Engineers Ireland after 2013.

In this paper, one of the engineering programmes is covered in detail (Manufacturing Engineering with Business Studies). Also, a survey expressing a number of student’s opinions as well as obstacles for the Bologna process based on the survey results are presented.

INTRODUCTION
The School of Mechanical and Manufacturing Engineering undertakes four undergraduate BEng degrees worth 240 ECTS each. The courses are Mechatronic Engineering, Bio-Medical Engineering, Mechanical and Manufacturing Engineering and Manufacturing Engineering with Business Studies. The course Manufacturing Engineering with Business Studies will be presented in detail.

MANUFACTURING ENGINEERING WITH BUSINESS STUDIES
The specific objectives of the program me are [3]:

1. To provide a firm foundation of engineering principles, mathematics and computing.
2. To promote the use of computer based tools and their development for a wide range of engineering applications, including design, manufacturing marketing and plant operation.
3. To allow students to carry out in-depth studies of the core and option subjects, and in-depth investigative studies of projects chosen from relevant areas.
4. To enable students to be familiar with the principles of enterprise management and with basics of entrepreneurship.
5. To familiarize the students with aspects of business, economics, and HRM pertaining of engineering product development and industrial practice.
6. To enable the students to learn effective engineering communication practice.
7. To involve the students in engineering practice through the period of INTRA placement in industry.
8. To enable graduates to attain the status of Chartered Engineer in Ireland and internationally.
9. To enable graduates the opportunity to communicate engineering concepts and ideas and to assimilate, interpret and evaluate information in English and German or French.

Currently, all undergraduate courses in the faculty including Manufacturing Engineering with Business are completed in four years with an optional one-year taught masters. Each year is worth 60 ECTS. The INTRA work experience program is carried out in the second semester of 3rd year (worth 30 ECTS of the 60 ECTS for that year). If the system of education is changed from 4 years undergraduate to three years undergraduate, then the INTRA work experience would be moved to the newly created two-year masters program instead. Before implementing these changes, it is of utmost importance that the opinion of students is consulted. Thus a survey was carried out as explained below.

**STUDENT SURVEY**

In the survey carried out, 19 students participated. Twelve were postgraduate students, six were masters or PhD graduates and one was a bachelor degree graduate. All students were asked the same questions. Nine participants completed the questions online while the remainder were completed on paper. The questions were selected based on requirements of compliance with the Bologna Treaty to support the engineering industry with excellence [3].

- High quality of technical knowledge
- To be able to learn, develop and improve
- To be flexible in adapting to change
- To be able to manage and motivate employee
- To be able to manage project and event
- High communication quality
- Focus on business
- Team working and multidisciplinary nature
- Proving leadership and vision
- Commitment to ethical and social responsibilities
- Commercial and financial knowledge
The survey that was carried out contained the following questions:

Are you

- An employed Bachelor degree graduate? 
- A post-graduate Student? 
- A Masters/PhD graduate?

Please tick the boxes for the following statements according to highest relevance (Strongly disagree = 1; Disagree = 2; Neutral = 3; Agree = 4; Strongly agree = 5)

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<td>A one-year taught masters would be too short and demanding</td>
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<td>2</td>
<td>I have acquired sufficient quality of technical knowledge from my university education</td>
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<td>My increase in personal development is largely due to my work completed in university</td>
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<td>My university education has provided me with much project and time management skills</td>
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<td>Sufficient team-work practice have been provided in my university education</td>
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<td>Sufficient practice to adapt to change has been provided in my university education</td>
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<td>Ethical and social responsibilities has been sufficiently addressed in my university education</td>
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<td>8</td>
<td>Sufficient commercial, business and financial knowledge has been acquired in my university education</td>
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<td>9</td>
<td>My modules have given me much advantages in finding employment</td>
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<td>10</td>
<td>My modules have been used extensively in my work after graduation</td>
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Would you prefer

- 3 year undergrad with 2 year masters postgraduate? 
- 4 years undergrad with 1 year masters postgraduate?

Is there any subjects or modules that you have considered of benefit for your work after graduation? If yes, please suggest them: ________________________________________
RESULTS AND DISCUSSION
The survey results as well are outlined below. A very large percentage (55%-60%) of students were neutral on the opinion of the taught Masters course being too short and demanding. This may be due to the fact that many participants have not undertaken the taught Masters programme. However almost double the number students were in agreement than in disagreement or strong disagreement with the length and demand of the taught Masters course.

![Figure 1: Results from student opinion survey.](image1)

![Figure 2: A one-year taught masters would be too short and demanding](image2)

![Figure 3: Acquired sufficient quality of technical knowledge from my university education](image3)
It has been well established here that students are satisfied with their acquirement of technical knowledge in their undergraduate studies. Only two students were in disagreement with sufficient technical knowledge provision.

Figure 4: My increase in personal development is largely due to my work completed in university

Figure 5: My university education has provided me with much project and time management skills

Figure 6: Sufficient team-work practice has been provided in my university education
A similar opinion of agreement was found for the acquirement of personal development, project and time management, team work and adaption to change in the old (4+1) system. As aimed by the department of Mechanical and Manufacturing Engineering and Engineers Ireland in recent years, ethics and social responsibility has been adequately addressed according the students studied.
However 74% of students were either neutral or sceptical about the covering of commercial, business and financial knowledge. Manufacturing Engineering with Business Studies clearly satisfies this but other courses appear to not do so. Only 7 students believed that adequate advantage has been provided in the modules covered for finding employment after graduation. Many (63%) participants were unsure whether the modules covered in their studies were used extensively in the workplace as many students who participated have had very limited experience in employment.

![Figure 10: (a) My modules have given me many advantages in finding employment and (b) My modules have been used extensively in my work after graduation](image)

![Figure 11: Students in favour of retaining 4+1 degree (11) instead of adopting the newly proposed 3+2 degree.](image)

However, it was found that 11 of the 19 people favoured the traditional system of 4 years undergrad with 1 year optional taught masters. Another optional question in the survey included asking for a most relevant subjects studied. Subjects based on finite element
analysis were mentioned three times while mechanical mathematic based subjects and CAD was nominated twice. Other listed subjects included design and production, advanced manufacturing processes, polymers, control systems and communication engineering.

CONCLUSION
It has been established in the survey that there is definitely a need to introduce more business education in the engineering curriculum with exception to the Engineering with Business Studies course. Also, great demand for more computer based design studies such as finite element analysis and CAD in future undergraduate course has been established.

There seems to be overall satisfaction with the current 4+1 format (4 years undergraduate and 1 year optional taught Masters) of engineering education with DCU graduates and post-graduates. It is unsure as whether extending the taught Masters course to two years would be popular with the next generation of undergraduate students.

If the engineering courses are changed to a 3+2 format (3 years undergraduate and 2 years optional taught Masters), it may well be against the wishes of many who only want a Bachelors degree as well as a four year engineering education guaranteed. The main advantage of adopting a 3+2 year system would be apparent if there would subsequently be a common system of qualification measurement for all nations involved.

REFERENCES
TEACHING ENGINEERING STUDENTS

Plato Kapranos and Panos Tsakiropoulos

Department of Engineering Materials, The University of Sheffield, Sir Robert Hadfield Building, Mappin Street, Sheffield, S1 3JD, UK
E-mail: p.kapranos@sheffield.ac.uk

ABSTRACT
Education has a number of vital roles to fulfil, such as the development of constructively and critically thinking students, the empowerment of citizenship towards the creation of a better society, generation of awareness of issues of equality and justice, and finally promoting the vital fact that in a society there are ‘responsibilities’ as well as ‘rights’. In addition, education indirectly also contributes to the wealth creation sectors of society providing the vital competitive edge required to survive or thrive in the global marketplace. This paper presents some thoughts on teaching engineering students. Interrelated issues of education and training of significance to engineering are considered and basic theories of teaching are briefly discussed from the viewpoint of engineering.

INTRODUCTION
We live in a fast moving world where nations have less and less control over their destinies. There is need for a broader vision of education, the vision of the common social good and the development of human potential to its full capabilities. ‘The global economic reality is one where a sports car which is financed in Japan, yet it could be designed in Italy, assembled in Indiana, Mexico and France, will then use advanced electronic components invented in New Jersey and will finally actually be constructed back in Japan. There will be no more national products and technologies, no national corporations, no national industries. There will no longer be national economies. All that will remain rooted within national borders are the people who comprise the nation. Each nation’s primary assets will be its citizens’ skills and insights’ [1].

In an educational context, globalisation presents us with a series of challenges:

- Education and training is seen as the principal means of increasing national economic competitiveness,
- Ageing populations and workforces will require expansion of post-compulsory education and re-training,
- More and more voters might not subscribe to subsidizing this trend for lifelong learning.

Education has a key role to play in dealing with many of the societal problems and challenges that face us. However, at least in the short term, it seems that in the developed countries the loss of manual labour intensive markets has been accepted as being inevitable and that there is only one alternative, i.e. to proceed towards the hi-tech niche end of the market. This decision is said to be based on pragmatism but on the educational
front it might turn out to be short sighted. The engagement in expensive educational and training programmes, which provide flexible, adaptable and highly skilled workforces that are ahead of the competition from the poorer countries, might be a sure way to keep ahead of the competition, at least in the short term but provide us with reasons about its utility only in economic terms. One must not lose sight of the fact that this is only a part of the overall educational strategy and that enhancing national competitiveness by subordinating all welfare policies to the needs of a competitive economy might lead to social disengagement and strengthen further selfishness in society reinforcing all the trends that were wrong in the selfish society that was promoted in the 1980’s.

One must look carefully at the long-term effects of such decisions in the context of the overall efforts to maintain our privileged economic position in the current world order. It is simply not good enough to apply the economic free market principles in formulating educational strategy because any disturbances that are created in the value/ethics system through education will not be ironed out by the laws of supply and demand. Such disturbances not only can have a much longer shelf life and can last for generations, but they are very difficult to remove or alter in the short term. In our professional capacity we should always try to emphasise this to engineering students; there is the tendency to expect technological progress to get us out of the various messes we find ourselves in and technology usually delivers, however, technological developments do not happen overnight, they take time and this is where the break down occurs in free market forces models as an answer to everything.

Engineering provision in a modern university cannot be divorced from consideration of the nature and purpose of universities, “what is a university for?” In 1984, Newman addressed this question and some of his ideas are still important regarding contemporary universities [2]. An ambition of this paper is to draw attention to interrelated issues of education and training of significance to engineering. Given the breadth of the topic and the limited space of a conference paper, we only touch selected issues that we consider to be important.

**IDEAS & ASSOCIATIONS**

The word *technologia* (the origin of the word technology) means making, producing, constructing, and building, having made a detailed account of the matter or question, with explanatory reasons, logical basis and exposition of principles. In the East and West Roman Empires the word *technologia* also used to imply the logical and rational development and application of tools, machines, materials and processes that helped to solve human problems.

In Latin the word *ingenium* (the origin of the word engineering) means skill. Nowadays, engineering means the art and science by which the properties of matter are made useful to man, whether in structures, machines, chemical substances, living organisms and the design of complex systems that perform useful functions. According to the Royal Academy of Engineering and the Engineering Council of the UK, engineering is *the knowledge required* and the process applied to conceive, design, make, build, operate,
sustain, recycle or retire, something of significant technical content for a specific purpose; a concept, a model, a product, a device, a process, a system, a technology.

The distinct inputs that are expected of engineering courses and degree programmes offered by tertiary education in advanced countries were highlighted above. It should be noticed that engineers graduate from institutions of higher education that often use the word technology, but not engineering, in their titles, e.g., MIT, ICSTM etc.

Education and training are closer related in early life experiences but diverge more and more as we move higher in education. In universities students study and academics expect them to become more self-directed as they progress in their studies. In engineering education and training a large part of the academic’s task must be to equip the student with the means to pursue inquiry on his or her own part, to instigate self-directed study. Modularity was intended to make university subjects student-centred not subject centred.

The word education signifies to be led and thus “points to a subservient relation between those who are being educated and those who are educating them” [3]. The Greek word μορφώση implies “what educates us, forms us”. Education is for the whole, the complete, person.

In ancient Greece knowledge is proven to be true only when it is verified by common experience (Heraclitus’ “αληθεύειν εστί κοινωνειν”), only when it is shared with others. This is a direct result of the definition of the man/woman who is a person (= προσωπον), which signifies that s/he has his/her face (= ωψις) towards (= προς) someone or something: that s/he is opposite (in relation to or in connection with) someone or something. In other words, man/woman exists only in comparison with every other existence, only in relation to, in connection with another person [4].

“It is persons that educate and train”, not courses; between academic and student “successful collaborations often arise fortuitously and spontaneously” [5]. The energy embedded in examples and case studies is what educates and trains in engineering.

The mastering of any engineering subject, the getting inside it, is the same as mastering its particular modes of thought. If universities were to reduce thought to just teaching, this would actually stifle thought [6]. There is progress when students are able to continue the intellectual activity that constitutes their subject beyond anything they are taught, or as Newman put it “Gentlemen….you have come, not merely to be taught, but to learn” [2].

The mastering of any engineering subject must include assessment and revisiting. Modularity often threatens the latter. Some parts of a subject can be used in another, but it still needs a different whole to belong to. Skilful course designers ensure that courses have structures that allow key parts to be revisited. Universities are for taking things further. Their engineering students after graduation may go to all lengths of research.
The engineer needs to know (among other things) “hard” facts, truths which, when we
know them are, in Newman’s terminology, “exhausted” and thus can be securely acted
upon [3]. As pointed out by Graham, Newman distinguishes between “education” and
“instruction”, between “the philosophical” and the “mechanical”, the former being
characterised by an introduction to “general ideas”, the latter with information “that is
exhausted upon what is particular and external”. Newman’s distinction has to do with the
different direction of thought that alternative forms of enquiry take [3].

“Those who engage in learning as opposed to instruction are set upon a course - the
investigation of general ideas - which in turn implies a different relation between learning
and the mind which learns than the relation implied in a process of “instruction”. Newman
does not claim, and no one needs to, that education is superior to instruction, only that it is different” [3].

Following Graham, we can replace the language of training versus education with one
which contrasts technical with liberal education [3]. “Newman’s idea of the university
providing a liberal education, even to those training for the professions, e.g., engineers
and scientists of every kind, and thus making them even better engineers and scientists ,
became the idea of the university”[6]. Newman knew that technology and engineering
subjects can provide intellectual stimulus; “no one can deny that commerce and the
professions afford scope for the highest and most diversified powers of the mind” [7].

Technological and engineering education must “in part be intellectual and affords scope
for the highest and most diversified powers of the mind” and the exercise of the powers
of the mind that technology and engineering require is not required for its own sake, but
for the sake of another end. Intellectual enrichment is a form of wealth [3].

Professionals need an understanding of the significance of their profession. What is it to
be a chemical engineer in charge of a petrochemical plant? Why are chemical,
mechanical and metallurgical engineers employed in a petrochemical plant? Without
some consideration of these questions, the respective practitioners of these professions
are mere functionaries, reduced to servers and not formers of social life; “Liberal
education embellishes the technical and technological to create the professional” [3].

The education and training of engineers has been affected by the eagerness to engage
students with so called useful topics, something that mirrors an earlier fixation with
relevance [3]. Engineering topics have to be relevant to something; everything useful
must be useful for something.

There is an attempt to eliminate the distinction between education and training by
concentrating on skills; “because skills will increase GDP”, skills are something you can
do something about and something worth the doing.

Academics are often required to provide an adequate explanation of the value of
university education. Even though finding arguments to explain the value of engineering
training is not difficult, it is crucial to observe the following:
that engineering education is not just the acquisition of skills and
that justification in terms of transferable skills offers no support whatever for the
content of subjects; “The error in the appeal to transferable skills does not lie in
its falsehood, but in the fact that it attempts to explain value in terms of use” [3].
“Current political rhetoric about the competitive world flatly contradicts the part about
transferable skills, for it is often recognised that skills are not transferable, that training
in one process will not do anything to prepare you for other processes; we must therefore
be ready and willing to re-train” [6].

TEACHING ENGINEERING STUDENTS
There are various theories of teaching as shown in the table below:

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<td><strong>SIMPLE THEORIES</strong></td>
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<td>The verb ‘teaching’ is applied to the academic subject. It is likely to be one with a lot of detailed facts to learn.</td>
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<tr>
<td>The verb ‘teaching’ is applied to people. The subjects are related to personal attitudes and skills.</td>
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The basis of the transfer theories is the fact that the subject material is viewed as a commodity to be transferred to the students’ minds and successful learning is seen to be the result of well-prepared material, effectively organised and imparted. Unsuccessful learning is seen to be the consequence of poorly motivated, unintelligent, lazy, forgetful students. The conventional form of lecturing is seen as a classical manifestation of a transfer theory in action. As such, the conventional lecture has been described jokingly as being ‘an occasion when the notes of the lecturer become the notes of the students without passing through the minds of either’.

To metaphorically demonstrate the transfer theories we can consider the themes of ‘the students being considered as empty vessels to be filled by the teacher’, or ‘the baby food analogy where the teacher is processing very tough material into more easily digestible nutrients for rather simple minds’. All that is required of the teacher in these theories is the delivery of his nuggets of wisdom, ensuring the purity of the seed.

In a similar way the shaping theories view students, or their brains, as raw material (metal, wood or clay) to be shaped, or moulded or turned to a predetermined and often
detailed specification. In the shaping theories the teachers ‘develop’ or ‘produce’ engineers, doctors etc. Shaping apparently happens through the sheer force of the spoken word and the authoritative presence of the expert on this controlled, passive raw material. These theories are akin to indoctrination, training and instruction, rather than education (see Figure 1). We must be able to draw the distinction between these concepts because shaping theories have value and can be effective when used in the appropriate contexts of training, instruction and indoctrination.

Figure 1: How different aims are associated with the different approaches to learning [9].

There is a plethora of research on Teaching & Learning and it is beyond the scope of this paper to attempt anything more than making this clear. There is an illustrious list of contributors to our understanding of these topics, however, I will try to pull this section together by considering two papers that have direct relevance to the choice of my theme and are influential to my own teaching approach [8, 9].

A hybrid theory, lying between the simple and developed theories, is the Building theory. This theory views the student’s brains as building sites where the subject matter is delivered as raw materials, a load of bricks, but then it requires the building of a complex structure (a concept) to be built by suitably arranging the various interrelated building elements. Therefore, teaching involves more than the simple delivery of materials, but it involves building a structure according to a predetermined plan. Although in the face of it this is an advance on the simple transfer theories, it still leaves us with a ‘static’ model of knowledge and a ‘closed’ system approach to teaching and learning. If however, we allow the actual construction of the concepts to be carried out by the students in accordance to their own experiences, abilities and motives, thus allowing them to become
significant contributors to the direction and efficiency of their own learning, this theory can be on the way to be classified as a developed theory.

The essential element of the simple theories is that the teacher is or should be in full control of the commodity being transferred (transfer theory) or of the shape and size of the final product (shaping theory). The end product in both cases ought to be predetermined and in this simple relationship between teaching and learning, if something has been taught it must have been learned. The role of the student in these theories is a passive one.

In contrast, the essence of the developed theories is that the students become contributing partners in their own learning. In the developed theories the students become fellow travellers (travelling theory) or they are helped along by the teacher or expert but they also make significant contributions to the process and pace of their learning as well as the direction and the objectives (growing theory).

The job of the teacher becomes that of a ‘coach’ who uses his experiences and expertise to help students to organise their ideas and utilise their talents in order to appreciate their experience and what is to be mastered ahead of them. The teacher will ‘guide’, ‘point the way’, ‘lead’ on what becomes a joint journey of exploration. The teacher is there as someone who has seen it all in context but he/she is still exploring, being aware of the continuous changing scenery, knowing that there is always something new to learn and happy to share this experience with newcomers. In this scenario, the teachers themselves are open to seeing things from the perspective of their students and often being enriched by the experience of seeing something from a different viewpoint or discovering something totally new. The experience and knowledge of the teachers is of great value in this kind of exploration because it can be used to provide the appropriate feedback on their developing skills and knowledge therefore assisting their continual improvement.

Once again, there is a debate if the journey should be a ‘pure exploration’ or a ‘guided tour’. There are merits in both and we see no great contradiction in a free flowing guided tour. I have been a recipient of such a guided tour in exploring the beauty of ancient Ephesus. Although we had to explore it within certain guidelines, the exploration was interactive and as a result I have both learned something from the guides but I have also taught them few things myself, feeling satisfied that we both had gained from the experience. It could be argued that ‘if you do not know your destination how would you know when you got there?’ That can be countered by saying that Columbus discovered the Americas by having the idea that China could be reached by sailing West. Clearly he did not reach his planned destination but how many of you can argue that his exploration did not fundamentally change the course of human history? Once again we do not see a great contradiction of having set targets (objectives) but allowing the flexibility to explore outside these.

Although the role of the teacher in the developed theories is a more human and responsive role, and of course the student’s involvement and input become a crucial part of the learning process, there is a distinction on the emphasis, i.e. the travelling theory
emphasises the subject whilst the growing theory emphasise what is happening to the student as a person. Both these theories place less emphasis on ‘teaching methods’ but emphasise the ‘teaching strategies’, ‘learning activities’ and ‘learning experiences’.

Ithaka by C.P. Cavafy
When you set out for Ithaka
ask that your way be long,
full of adventure, full of instruction.
The Laistrygonians and the Cyclops,
angry Poseidon - do not fear them:
such as these you will never find
as long as your thought is lofty, as long as a rare emotion touch your spirit and your body.
The Laistrygonians and the Cyclops,
angry Poseidon - you will not meet them
unless you carry them in your soul, unless your soul raises them up before you.
Ask that your way be long.
At many a summer dawn to enter
-with what gratitude, what joy-
ports seen for the first time;
to stop at Phoenician trading centers,
and to buy good merchandise,
mother of pearl and coral, amber and ebony,
and sensuous perfumes of every kind,
sensuous perfumes as lavishly as you can;
to visit many Egyptian cities,
to gather stores of knowledge from the learned.
Have Ithaca always in your mind.
Your arrival there is what you are destined for.
But do not in the least hurry the journey.
Better that it last for years,
So that when you reach the island you are old,
rich with all you have gained along the way,
not expecting Ithaca to give you wealth.
Ithaca gave you the splendid journey.
Without her you would not have set out.
She hasn’t anything else to give you.
And if you find her poor, Ithaca has not deceived you.
So wise have you become, of such experience,
that already you will have understood what these Ithakas mean.

A first degree in engineering involves “A course that is broad and structured in a substantive field of knowledge which gives the learner an insight into the limits of knowledge as well as some of its domains. There is a natural tension in engineering between doing tomorrow what was done yesterday and being innovative. The principles cannot be effectively elucidated without a basis of facts and knowledge of engineering
systems, so it is not a matter of one thing or another, but of balance, giving engineering students conceptual spectacles through which to view the world” [9]. If we allow ourselves to see the variety in the way we learn, then we can appreciate the need for a variety in teaching approaches. The more flexible one is in their teaching strategies, the better chance they have to accommodate the different ways of learning of their students, which after all is only a reflection of the natural differences in cultural, social, previous knowledge levels, experiences, and all the other ‘baggage’ we all carry within us as individual human beings.

However, there is one more point to be stressed, it is not only how well intentioned we are in our approach and how well we articulate our aims and objectives, but how well and what the students understand those objectives to be. It is not how well we design assessments to test understanding rather than reproduction, but what our students believe the assessment to be about. Any mismatch between these perceptions and the effectiveness of what we are trying to achieve will be severely reduced. Different students, as all of us, perceive the same context in different ways. If we are lucky enough to establish a rapport with our students and both are on the same ‘wavelength’ then we can both reap the benefits of the developed theories of learning. However, if any mismatch occurs in the perception of the learning process from either side, there will be frustration and disillusionment all around.

Engineering suffers from too much emphasis on knowledge and teaching and not enough on technology and learning. Assessment needs to be part of the learning process and it should be for the benefit of the student and not for the criticism of the students by staff or the teaching staff by their students. Assessment should be a step model rather than a hurdle, i.e. the growth in students’ progress and level of understanding should be achieved through incremental steps that sequentially reinforce their learning rather than expected to occur in an almighty single burst of insight, although that does happen. There are both pedagogical and economic advantages in adopting the Bologna model in engineering education, i.e. a not too demanding first degree with little or no professional pretensions, followed by a more demanding specialist second degree for those selected through motivation. The first degree would be largely tacit knowledge based, utilising the Internet as a teaching tool, with problem based learning, case studies and work placements to construct experiences based on knowledge and skills. The second, professional degree is where the engineering leadership will be moulded through strictly explicit knowledge that reflects the high expectations of the aspiring professional engineers. Although this approach seems to stand everything that we hold so dear in engineering education on its head, it is only an illusion. We have been approaching engineering education mainly on tradition, i.e. it has always been done that way. We must build the professional engineers by immersing them in vast amounts of explicit knowledge, irrespective how much of that knowledge they will use in their professional careers. What this new approach proposes is not doing away with explicit knowledge that is invaluable to engineering, but instead is asking us to allow selective transmission of such knowledge to those in the engineering profession that are motivated to use it. After all an engineer is someone who finds creative solutions to problems [10].
Teaching is all about creating the appropriate ‘environment’ for learning to take place. If we are given the serious task of educating or influencing minds (young or old), the least they deserve is the commitment from us that we will do our best to facilitate the process of learning. Of course that takes us back to the issues of ‘What constitutes education/learning?’

Should education be about the development of the individual, or should education focus in meeting the requirements of society? Should education manifest itself as the development of the individual or as a set of skills and knowledge that will get the individual employment? There is clearly a dichotomy of purpose and this dichotomy manifests itself through the various curricula. However, although the social and individual needs are not the same, they do clearly overlap. There is need to see the commonalities of purpose as the base of an education that fulfils both tasks at the same time. It must be understood that education is multifaceted and it must serve a number of purposes. In addition, rather than viewing the educational purposes as neat little linearly connected boxes, they could be envisaged as part of a 3-dimensional continuum all interconnected, each having an influence on the others and vice versa [11]. In our search for a meaning, we might be forced to step back and reflect before jumping onto whatever bandwagon is fashionable in educational circles (that does happen).

Teachers, like anybody else nowadays, must be allowed to draw back occasionally, to concentrate on things that really matter. Being buried under bureaucratic paper mountains is not conducive to reflecting on the world that we are occupying or the purpose of why are we here? Teachers must be allowed the freedom not only to ask the question ‘Why Teach?’ but given the time to seek the answers and the space to act on their answers.

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THE CHANGING FACE OF RESEARCH'S EFFECT ON ENGINEERING EDUCATION

Patrick Murphy

University College Dublin
E-mail:patrick@spudmurphy.ie

ABSTRACT
In old Ireland, engineering research and teaching were separate silos of activity. With the modern drive towards a knowledge-based economy, research has increasingly taken up a bigger chunk of academics' time and priorities. Under the government's policies of increasing research and development funding for both universities and individuals, the number of masters and PhD students have increased massively and attracted interest from across the globe.

In this presentation it is hoped to investigate the effect this increased research focus has had on the education of the country's future engineers, in both a positive and negative light. The changing of one of the country's leading engineering universities to meet this challenge will be looked at as a case in point. The influence of industry, and its increasing interest in research and commercialisation of same, will also be looked at within the scope of its effects on tomorrow's engineers.

Ireland twenty years ago leveraged its young, educated workforce to become the economy that it is today. This asset brought the likes of Intel, Dell, Microsoft, Google, Wyeth, Elan and many other high technology companies to our shores. In today's somewhat less uncertain economic times, a change in the balance of the assets that created our success could be detrimental.

After looking at the three case studies outlined above, and comments proffered by researchers and educators in the field, a clear picture of Ireland's current position will be seen. Around this picture, a key question will be asked: has the balance of the forces that created Ireland's success changed, and has this change of focus had a positive effect thus far in Ireland's development? To conclude, proposals for what needs to be done to keep newly educated engineers on our island as employees of Ireland Inc. will be presented.
A GRADUATE CAPABILITY FOCUSED TOP DOWN APPROACH FOR DEVELOPING THIRD LEVEL PROGRAMMES

Saleem Hashmi

School of Mechanical and Manufacturing Engineering, Dublin City University
E-mail: saleem.hashmi@dcu.ie

ABSTRACT
Employers of engineering graduates are looking for what exactly the new recruits can do as opposed to just what knowledge base they have. For any Engineering Programme it has to become more important to ensure that each subject taught identifies a definite link to a set of “Learning Outcomes” or “Ability Markers” which the student completing that subject/module will acquire.

When developing a new programme, the approach taken can be top down in which the graduate’s capabilities are identified first. This follows selection of subjects/modules with associated “Learning Outcomes” which provide the foundation for the competence and capability of the graduates.

The alternative is the “Bottom Up” approach in which all the modules are compiled and the Learning Outcomes of each module are established and listed. The Programme Learning Outcomes are then synthesised from the global list of the module Learning Outcomes. This approach suits better for reformatting existing programmes which have not been previously planned in the context of Learning Outcomes.

In the presentation, the Top Down approach for planning couple of engineering degree programmes will be illustrated in a step by step procedure.

Additionally, an exercise will be given to the audience for Top Down planning of the structure of an arbitrary degree programme to re-enforce the presented procedure.
Student Teaching and Assessment Methods
THE TEACHING OF SUSTAINABLE DEVELOPMENT
AT ASTON UNIVERSITY

John Fletcher, George Drahun, P. Davies and P. Knowles

School of Engineering and Applied Science, Aston University,
Aston Triangle, Birmingham, B4 7ET, UK
E-mail: j.p.fletcher@aston.ac.uk

ABSTRACT
The teaching of sustainable development is carried out at Aston University through the use of a role play of the expansion of a factory making plastic windows. The learning objectives and outcomes have remained unchanged but the way in which they are taught has changed significantly.

Teaching makes extensive use of a commercial virtual learning environment to support student interaction. Students are assessed directly on social and technical aspects, including assessing the impact of the raw materials used for the process. The project ends with the role play in the form of a planning enquiry.

Students are given assistance to understand the social roles which they have been assigned. This is provided using one-day role plays and by requiring a two page written profile of the role from each student early in the project. This is supported by briefings for each group from the tutor. Also, the tutors guide the role play by simulating topical external events such as a general election, or taking extra roles e.g. visiting government official.

This has now become an established part of the programme for final year students of chemical engineering and mechanical design. It is necessary to explain carefully the significance of it to the students.

INTRODUCTION
Previous papers have discussed the introduction of the teaching of sustainable developed at Aston University through the use of role play [1, 2]. This work was developed through the funding provided by the Royal Academy of Engineering for a visiting professorship.

The most widely quoted definition of sustainable development is “…ensure that development meets the needs of the present without compromising the ability of future generations to meet their own needs” [3].
Sustainability achieved through sustainable development is accepted globally at government level and is receiving attention within large organisations and professional institutions as a significant objective for future development.

To support the continuing advance of the concept it is essential to convey the sustainability message to future generations through the education system. One of the recommendations made by the UK Government’s Sustainable Education Development Panel is that by 2010 all professional and industry lead bodies should have sustainable development criteria included within their course accreditation requirements [4].

Since 1998 the Royal Academy of Engineering has funded five visiting professorships each year at UK Universities to prepare and deliver teaching material on the subject of sustainable development. The funding is provided initially for three years with a two year extension option. The teaching material from all the participating Universities will eventually be made freely available to all Universities. Aston University was successful in its application for a visiting professorship in 2000 and the two year extension was granted in 2003.

The Aston visiting professor’s sphere of activity has been defined as the provision of teaching material for the whole of the School of Engineering and Applied Science: Chemical Engineering and Applied Chemistry, Mechanical, Electronic and Civil Engineering and Computer Science.

The visiting professorship came to an end in 2005. The work described in this paper is a continuation of the teaching of sustainable development using role play which has now become an established part of the programme of several engineering degree courses. The students are studying within the disciplines of mechanical and chemical engineering and it is an important part of the work that they undertake in interdisciplinary groups. The numbers of students involved have increased to the point where each year two parallel groups are run, on two different but similar projects, each involving the expansion of a factory and the associated need to apply for planning permission. One project is on the manufacture of plastic windows, and the other on the manufacture of cars. One is set in a city suburb and one in a smaller town.

The School of Engineering and Applied Science has been using WebCT as the virtual learning environment for teaching, and we use this [5]. This provides a database, communication and progress monitoring. University level support is provided for WebCT.

The role play work of the students is always accompanied by technical work evaluating the economic, social and environmental impact of the materials involved. One of the techniques which was introduced by the visiting professor was the use of life cycle assessment for the study of the impact of technology on society. This was discussed in the teaching material and some use of it was made in the project work.
The social role play work has to be supported and guided by the tutors from their knowledge of the ways in which society functions. The assumption cannot be made that final year students will be familiar with the mechanisms of local government, and the roles of the parts they will be called on to play. A vital part of this is enthusiasm and a sense of fun, taking on extra roles when needed and stimulating the students to face some of the difficulties which can arise. Also, opportunity has been taken to involve other members of the university, by inviting them to chair the final enquiry session of the project.

**BACKGROUND**

**Sustainability and Education**

The Earth Summit in Rio de Janeiro in 1992 adopted a global action plan for delivering sustainable development [6]. This includes the statement that “education is critical for promoting sustainable development and improving the capacity of the people to address sustainable development issues”.

As a signatory to Agenda 21 the UK government has actively promoted sustainable development education. A strategic approach to this is directed by the Sustainable Education Development Panel [7]. The panel’s objectives include the consideration for the setting targets for various sectors of education if appropriate, the highlighting of best practice and its means of dissemination and recommendations to key stakeholders on priority areas for action.

Until recently there has been a lack of sustainable development teaching on engineering courses within Higher Education. A survey of Universities in the UK and abroad suggested that students have a poor understanding of fundamental environmental issues and little knowledge of sustainable development [8]. Forum for the Future has also investigated engineering curricula in the UK and issued a range of documents addressing the teaching of sustainable development [9]. The need has been identified for teaching material on the subject and this has led to the Royal Academy of Engineering’s initiative.

**The Structure of Sustainable Development**

Sustainable development is described as resting on three pillars, also called the “triple bottom line”. These pillars are economic growth, protection of the environment and social equity.

Most technology and development issues have been decided in the past on an economic basis. The sustainable development approach has to consider the trade off between local and remote consequences and also short term and long term impact. Sustainable development is not designed to answer all the questions pertaining to a design problem. All it can do is to clarify and generate discussion about the issues involved.

Engineering students traditionally are taught about the environmental and economic aspects but little about the social. It was decided to develop the Aston case studies to redress that imbalance to some degree. All three pillars must be addressed, but because of the way the teaching is organised there is increased emphasis on social equity.
It is intended to provide the students with an understanding of sustainable development and how it applies over the whole life cycle of a product from raw material through design, manufacture, use and final disposal. For all of these the impact on each of the three pillars needs to be addressed and considered.

**TEACHING METHODOLOGY**

The project is now established as a 10 credit final year module which is currently taken by students within Chemical Engineering and Engineering Product Design degree programmes. The students are organised into groups of up to five, with a mix of students from different disciplines.

The method of teaching is a mixture of lectures to introduce the material with tutorial sessions where each group discusses their progress with the project tutor. Extensive use is made of the computer laboratory for the student groups to interact and develop a database of information about the project. The student feedback for the current year has been very positive. When more than one project is running, the students on each project develop a separate database containing all the material collected during the project. This includes technical references on the materials, and also all messages exchanged between the social groups. The database is maintained within WebCT, which is also used for teaching and administrative material supplied by the tutors.

**PROJECT FORMAT**

The project format has been subject to some careful thought as a result of the experience gained. The current format is to introduce the students at the start to their groups and their social roles within the group, around the planning application for the expansion of the factory. A briefing paper is given which identifies these roles and at an early stage each student writes a short document giving the background and opinions of the person they are playing. This has helped greatly to overcome a problem experienced where some students failed to appreciate what was involved and engage with the work expected of them.

After this the students are introduced to the technical work, where each group is allocated a topic for which they have to provide an impact assessment. In this part of the work each group is contributing to an overall project effort to study all the materials relevant to the overall activity in the project, the manufacture of either plastic windows or cars. This means that the actual materials studied in the two projects are different, as shown in tables 1 and 2.

<table>
<thead>
<tr>
<th>Social</th>
<th>Technical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Media</td>
<td>Aluminium</td>
</tr>
<tr>
<td>Manufacturer</td>
<td>By-products</td>
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<tr>
<td>Unions</td>
<td>PVC</td>
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<tr>
<td>Local Residents</td>
<td>Chlorine</td>
</tr>
<tr>
<td>Council/MP</td>
<td>Electricity</td>
</tr>
<tr>
<td>Environmental Activists</td>
<td>Timber</td>
</tr>
</tbody>
</table>

Table 1: Student role assignments – plastic windows.
The project includes the preparation of a report by each group covering the social and technical work. The final activity is a session simulating the planning enquiry where each group presents its case.

**Social Roles**
The development of the social roles is an extremely important part of the project. All of the groups have an important part to play, but inevitably the group playing the manufacturers is a focus of attention of most of the other groups, and are called on to be inventive in setting the context of the company they are role-playing. This means that it is important to encourage them to work as a team with clear roles and responsibilities. They need a managing director, finance director, factory manager and personnel manager. They need to plan the expansion of their facility and submit a planning application.

Another group with a very important role is the media group. They are given the responsibility to produce an electronic newsletter each week and this is an important mechanism for the development of the themes of the project.

The local residents are set the task of choosing a name and geographical location for the project, so that discussions of local geography and transport problems have a clear context. They are encouraged to select identities covering a range of different situations.

The local government group needs a lot of careful briefing to understand their role in relation to the planning application which is central to the role play. They need to appoint a planning officer to liaise with the company over the actual application. Another member of the group role plays the local member of parliament, and the remainder local councillors, including the council leader. Each of these is encouraged to choose a political affiliation and then work within the constraints this introduces.

The trade union group is encouraged to have separate trade unions for middle managers and the workforce, and to have both workers and union officials in the team. This is another group which needs careful briefing to understand their roles.

The environmental activists have a clear role and are encouraged to campaign for their objectives with all the other groups.

It is encouraging that most of the students enter into this activity with enthusiasm and clearly gain insights which they would be unlikely to gain without this project.

<table>
<thead>
<tr>
<th>Social</th>
<th>Technical</th>
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<tbody>
<tr>
<td>Media</td>
<td>Hydrogen</td>
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<tr>
<td>Manufacturer</td>
<td>Steel</td>
</tr>
<tr>
<td>Unions</td>
<td>Hydrocarbons</td>
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<tr>
<td>Local Residents</td>
<td>Aluminium</td>
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<tr>
<td>Council/MP</td>
<td>Electricity</td>
</tr>
<tr>
<td>Environmental Activists</td>
<td>Biofuels</td>
</tr>
</tbody>
</table>

Table 2: Student role assignments – cars.
Events during the project
The progress of the projects is closely monitored by the tutors, at least one for each project. Two sorts of events are introduced; interventions to keep on track and external disturbances. Both will involve one or more tutors adopting extra roles as needed, in some cases more than one.

Each year the tutors plan an intervention designed to show that all does not necessarily go smoothly. In the year when there was a real general election, one was called within the project. More recently, there has been an intervention of a possible takeover bid for the company. This is extremely interesting as it focuses attention on the financial structure and corporate responsibility of the company.

FUTURE PLANS
The module will continue to be offered to final year students in the School of Engineering and Applied Science. The windows and cars projects have been run for several years. In the coming academic year there will be a change from WebCT to Blackboard for the VLE (Blackboard, 2008).

One of the responsibilities of the visiting professor was to “teach the teachers” in order that academic staff could supervise the project once the visiting professor’s contract had finished. This has been carried out to the extent that three members of staff are familiar with the project, assisted by a research student. This plan needs to be maintained by expanding the number of academic staff familiar with the project.

At the same time the teaching of life cycle assessment will be expanded using other modules which will mean that students will have experience of the technique before the start of the project.

CONCLUSIONS
The Royal Academy of Engineering’s initiative of funding visiting professors in sustainable development has given the School of Engineering and Applied Science at Aston University the opportunity to develop a project to provide teaching on the subject. Furthermore the project is expected to meet the future engineering institutions accreditation requirements in the area of sustainable development. The project has continued to operate after the end of the role of the visiting professor.

The salient benefits to the students include working in multidisciplinary groups, collecting and analysing information, much of it of a social nature, and presenting and arguing their points of view in front of potentially hostile colleagues.

The virtual learning environment software originally developed for the project has been replaced by a general purpose virtual learning environment, WebCT, showing that there is no need for the resources to support a separate package.
A longer version of this paper was previously presented at Innovation, Good Practice and Research in Engineering Education, organised by the Higher Education Academy Engineering Subject Centre and the UK Centre for Materials Education, [1]

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INTRODUCING MATERIALS AND PROCESSING TO FIRST AND SECOND YEAR STUDENTS

Marc Fry
Granta Deign Ltd.
E-mail: MarcFry@grantadesign.com

ABSTRACT
Engaging the interest of first and second year students is a challenge. In teaching students of Physics and of Materials Science it makes sense to start with the structure of the atom, building upwards through the physics of bonding, crystal structure and band theory, the thermodynamics and kinetics of alloys, finally arriving at material properties. Students of Engineering often find this approach too remote from the goals that motivate them. Engineers make and manage things. To select materials successfully, they need: a perspective of the world of materials, some understanding of the origin of the materials’ properties and how they can be manipulated, methods for selecting the best materials and processes that meet the requirements of a design, and ready access to data. This paper will present the methodology, tools and resources developed at the University of Cambridge and Granta Design that provide a simple, highly visual and engaging framework that helps first and second year students build a perspective, understanding and an enthusiasm for the subject of materials. It also aims to illustrate how these tools can be used to complement a range teaching and learning styles, including: design-led, science-led, and project-based techniques. The main emphasis of this paper will be to review how the main core of the CES EduPack teaching resource, the computer-based selection tool, can be used to introduce and engage students in the world of materials and processes. This incorporates a range of techniques, including: relating materials to everyday objects, the use of highly visual representation charts to illustrate material performance, the connection of materials to manufacturing techniques, the use of intuitive software tools that enable students to carry out material selection projects and the inclusion of textbook level Science Notes, in the material datasheets, that explain the underlying science of materials and material properties. In illustrating these aspects, the paper will also demonstrate how some of the newer areas of materials education, such as environmental impact and biomaterials, can be incorporated into introductory courses on materials.
AFFECTS OF STUDENT ATTENDANCE ON PERFORMANCE IN UNDERGRADUATE MATERIALS AND MANUFACTURING MODULES

Sumsun Naher, Dermot Brabazon and Lisa Looney
School of Mechanical and Manufacturing Engineering, Dublin City University.
E-mail: sumsun.naher@dcu.ie

ABSTRACT
This paper investigates the class attendance of second year, third year and fourth year students and their overall performance at the school of Mechanical and Manufacturing Engineering in Dublin City University (DCU). An investigation was recently conducted into the delivery of different module which was presented to a group of second year, third year and fourth year engineering students at DCU. Attendance in the class was recorded and the continuous assessment results and the final overall performances were investigated with their attendance. Student performance on Strength of materials – part 1 (SM1), Strength of materials part - 2 (SM2), Mechanics of Materials and Machine (MMM) and Advanced Materials and Manufacturing Processes (AMMP) modules are presented in this paper. This paper presents an examination of some of the factors affecting the overall results of these students. Factors evaluated include attendance of the student, as well as individual performance in continuous assessment and examination. Overall attendance at the lecture, the organised seminar series, and practical work were recorded. Results indicate a direct link between attendance and marks awarded. Students with higher attendance achieved better grades.

INTRODUCTION
Undergraduate engineering education has ‘changed very little over the last half of this century’ [1]. Regular reviews have taken place in many countries, but these have tended to focus on the subject content of degree courses, and its relevance to the needs of engineering employers [2]. However in 1990s, pressure for more radical changes began to build, for instance, in United Kingdom [3], Australia [4], the United States [5] and New Zealand [6, 7]. The motivation was a perceived need to improve the level of understanding by student, analyse their different learning styles and to examine ways in which student could get a deeper understanding of the required concepts in engineering. The ability to produce engineering graduates with educational standards comparable to the best in the world is critical to sustained economic growth with regard the formation, retention and attraction of high value added companies. Not only changing the learning environment, modern engineering education is so far enrich with full of resources, like e-learning facilities, web-based resources, distance learning and virtual learning. Most of these are for mature students who have self learning capacity.

Researcher found that the first year in college is a time for adjustment and turmoil for many late adolescents [8]. Some experience difficulties sufficient to cause them to drop out [9]. Academic performance and retention of college students has been studied extensively and theoretical models developed to describe various factors affecting college students’ adjustment and academic performance [10-14]. So, it is obvious that to have a proper learning environment it is necessary to investigate properly what are the point which effects student learning. In Ireland
researcher from all engineering discipline is now widely focusing on the student learning style, motivation, factors effecting and how to improve it from the present situation. These studies discusses current knowledge about effective teaching and learning in higher education and the implications for undergraduate engineering education.

METHODOLOGY

**Strength of Materials**
Strength of Materials is relatively traditional second year module for mechanical engineering students. Strength of material studied for the Computer Aided Mechanical and Manufacturing Engineering (CAM) degree and the Business and Manufacturing Engineering (BME) degree and also the Medical Mechanical Engineering (MEDM) students in their second year. In their first semester they do the first part of strength of materials (SM1) and in the second semester they do the second part of strength of materials (SM2). Each of SM1 and SM2 is a five full five credit course in each semester. The final exam accounted for 80% of the overall marks and 20% of the marks were awarded on the basis of the continuous assessments. Students’ regular attendances were taken. In 2008 there were 50 students in the first semester class and 56 students were in the second semester class.

**Mechanics of Materials and Machine**
Mechanics of Materials and Machine studied for the Mechatronic Engineering (ME) degree third year. Mechanics of Materials and Machine is a full five credit course half of which is focused on mechanics of materials like fracture, fatigue, creep and the other half of the module is focused on mechanics of machine. The final exam accounted for 80% of the overall marks and 20% of the marks were awarded on the basis of the continuous assessments. Students’ regular attendances were taken. In 2007 there were 13 students in the class and in 2008 there were 14 students were in the class.

**Advanced Materials and Manufacturing Processes**
Advanced Materials and Manufacturing Processes studied for the Computer Aided Mechanical and Manufacturing Engineering (CAM) degree and the Business and Manufacturing Engineering (BME) degree in fourth year. The advanced materials and manufacturing processes module is a full five credit course half of which is focused on materials and half on advanced manufacturing processes. The advanced materials part covers glass and ceramics, bio materials, materials characterisation, crystallography, and composites. The advanced manufacturing part of the course covers welding, design of experiments, laser processing, electron beam processing, and rapid manufacturing. Both parts of the courses include elements of research currently being undertaken within the Materials Processing Research Centre at DCU. As an example of this the students had to submit a continuous assessment reports on materials characterisation techniques for glasses and ceramics and on a high temperature and shear rate capillary viscometry laboratory experiment which they conducted. Some seminars complementing the course content were given by final year PhD students and postdoctoral researchers within the School. The final examination and continuous assessment were split equally between the materials and processes sections. The final exam accounted for 60% of the overall marks and 40% of the marks were awarded on the basis of the continuous assessments. Students’ regular attendances were taken. In 2007 there were 25 students in the class and in 2008 there were 22 students were in the class.
RESULTS
Table 1 shows Percentage of students which attended at the specified percentage levels for the three modules during 2006/07 and 2007/08.

Table 1 Percentage of students which attended at the specified percentage levels for the three modules during 2007 and 2008.

<table>
<thead>
<tr>
<th>% students attended in the class</th>
<th>SM1-07/08</th>
<th>SM2-07/08</th>
<th>MMM-06/07</th>
<th>MMM-07/08</th>
<th>AMMP-06/07</th>
<th>AMMP-07/08</th>
</tr>
</thead>
<tbody>
<tr>
<td>Attend.</td>
<td>0-20</td>
<td>20-40</td>
<td>40-60</td>
<td>60-80</td>
<td>80-100</td>
<td></td>
</tr>
<tr>
<td>0-20</td>
<td>6</td>
<td>20</td>
<td>7</td>
<td>7</td>
<td>4</td>
<td>-</td>
</tr>
<tr>
<td>20-40</td>
<td>20</td>
<td>28</td>
<td>29</td>
<td>32</td>
<td>24</td>
<td>20</td>
</tr>
<tr>
<td>40-60</td>
<td>40</td>
<td>45</td>
<td>43</td>
<td>40</td>
<td>20</td>
<td>24</td>
</tr>
<tr>
<td>60-80</td>
<td>26</td>
<td>5</td>
<td>14</td>
<td>14</td>
<td>28</td>
<td>34</td>
</tr>
<tr>
<td>80-100</td>
<td>6</td>
<td>2</td>
<td>7</td>
<td>7</td>
<td>24</td>
<td>22</td>
</tr>
</tbody>
</table>

Students were attributed an overall attendance level of either 0-20, 20-40, 40-60, 60-80, or 80-100%. The first two column of this table is representing the percentage attendance of the student in second year module. 40-60% is the maximum level of attendance for second year students for 07/08 year. The similar trend is observed in third year students. From this table, it is clear that fourth year students have more tendencies to be in the class than any other years.

The percentage attendance of student and their marks on 2007/08 for strength of materials can be seen in Table 2. From this table it is clear that, in strength of materials – part 1, higher the attendance higher the marks obtained. The highest marks obtained in both continuous assessment and examinations are by students who fall in the group of 80-100% attendance. The similar results are evident for the strength of materials – part 2 students. Strength of materials part 1 results are better than part 2, it is may be because of the more mathematical content in part 1 and more theoretical in content in part 2.

Table 2 Percentage attendance of student and their marks on 2007/08 for SM

<table>
<thead>
<tr>
<th>% Attendance</th>
<th>Total Marks_MS1</th>
<th>Cont Assmt_MS1</th>
<th>Exams Marks_MS1</th>
<th>Total Marks_MS2</th>
<th>Cont Assmt_MS2</th>
<th>Exams Marks_MS2</th>
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<tbody>
<tr>
<td>0-20</td>
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<td>17</td>
<td>26</td>
<td>4</td>
<td>21</td>
<td>A</td>
</tr>
<tr>
<td>20-40</td>
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<td>61</td>
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<td>51</td>
<td>62</td>
<td>49</td>
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<tr>
<td>40-60</td>
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<td>66</td>
<td>52</td>
<td>60</td>
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<td>60-80</td>
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<tr>
<td>80-100</td>
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</tbody>
</table>

The percentage attendance of student and their marks on 2007/08 for mechanics of materials and machine can be seen in Table 3. From this table it is clear that, in 2007/08, higher the attendance higher the marks obtained. The highest marks obtained in both continuous assessment and examinations are by students who fall in the group of 80-100% attendance. The similar results are evident for the 2006/07. One important observation from this table can be noted that the
tendency of being absent in the examination and also in the lack of participation of the class work and report submission are observed among lower attendance group. In this table ‘A’ stands for absence.

Table 3 Percentage attendance of student and their marks on 2006/07 and 2007/08 for MMM

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>0-20</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>13</td>
<td>65</td>
<td>A</td>
</tr>
<tr>
<td>20-40</td>
<td>A</td>
<td>A</td>
<td>A</td>
<td>36</td>
<td>44</td>
<td>34</td>
</tr>
<tr>
<td>40-60</td>
<td>55</td>
<td>69</td>
<td>50</td>
<td>58</td>
<td>65</td>
<td>56</td>
</tr>
<tr>
<td>60-80</td>
<td>54</td>
<td>74</td>
<td>50</td>
<td>45</td>
<td>60</td>
<td>52</td>
</tr>
<tr>
<td>80-100</td>
<td>53</td>
<td>77</td>
<td>47</td>
<td>65</td>
<td>53</td>
<td>68</td>
</tr>
</tbody>
</table>

Finally, the percentage attendance of student and their marks on 2007/08 for advanced materials and manufacturing processes can be seen in Table 4. From this table it is clear that, in 2007/08, higher the attendance higher the marks obtained. The highest marks obtained in both continuous assessment and examinations are by students who fall in the group of 80-100% attendance. The similar results are evident for the 2006/07. One optimistic observation from table 4, is that there are no student in the 0-20% attendance level. All the students are over 20% attendance. There were only one student fail in year 06/07 among 25 student and there were no failing was recorded in 07/08 among 22 students. It is also noticeable that students overall performance is better in 07/08 than 06/07.

Table 4 Percentage attendance of student and their marks on 2006/07 and 2007/08 for AMMP

<table>
<thead>
<tr>
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<tbody>
<tr>
<td>0-20</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>49</td>
<td>48</td>
<td>50</td>
</tr>
<tr>
<td>20-40</td>
<td>42</td>
<td>46</td>
<td>45</td>
<td>52.36</td>
<td>46</td>
<td>41.5</td>
</tr>
<tr>
<td>40-60</td>
<td>57</td>
<td>63</td>
<td>53</td>
<td>51.78</td>
<td>59</td>
<td>47.1</td>
</tr>
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<td>60-80</td>
<td>70</td>
<td>65</td>
<td>65</td>
<td>54.74</td>
<td>58</td>
<td>50.4</td>
</tr>
<tr>
<td>80-100</td>
<td>72</td>
<td>75</td>
<td>73</td>
<td>71.6</td>
<td>75</td>
<td>69.5</td>
</tr>
</tbody>
</table>

DISCUSSION & CONCLUSION
In most cases percentage marks obtained in continuous assessment are higher than the percentage marks obtained in the exam. Good continuous assessment performance did not automatically indicate good exam performance and vice versa. One student who secured 83% marks in strength of materials part 1, with a 80-100% in first semester, with 40-60% attendee this same student in the second semester was straggling to pass strength of materials part two. It would be interesting to investigate why he didn’t attend the second semester class as much as he did in first semester. Despite all the notes available in the moodle, he was unable to reach the same level of understanding.
The author considers that aspects of the traditional model of engineering education, such as widespread use of lecturers, the overcrowded content and the assessments methods used, do not lead to high quality learning. In addition, there is evidence that the overloaded content of engineering courses leads to many engineering students taking an instrumental approach to their studies. This is marked by a motivation to pass exams in order to obtain a degree (and hence a job), rather than being driven by an interest in learning [17]. Get rid of some extra syllabus, give the module a more realistic content. These authors has researched this and made some amendment in all these three module discussed in this paper.

To achieve improved learning, the course content delivery structure needs to be reviewed on a regular basis and made as clear as possible. In reality if engineering educators are to meet the goals of increased student numbers and improved teaching methodologies, a readily implementable system of Continuous Improvement (CI) needs to be an integral part of engineering programme structures [18, 19]. Methods that have been shown to be effective in improving content delivery include blended learning and access to the latest technology for facilitator and students. These methods also encourage and in many cases require student attendance which has been found here to be strongly correlated to their level of learning.

REFERENCES
2. Ibid, pp459-463
3. J. J. Sparkes, the future of first-degree engineering courses in the United Kingdom, Int. J. Eng. Edu, 9, 1, 1993, pp. 84-89.


ON THE INTRODUCTION OF IN-CLASS ASSESSMENT IN A THERMODYNAMICS MODULE

Reena Cole

Mechanical & Aeronautical Engineering Department, College of Science & Engineering, University of Limerick
Email: reena.cole@ul.ie

ABSTRACT
The method by which a subject is assessed will influence how students learn. Where a module is assessed by just an end of course or end of semester exam, it can lead students to learn just what they need to pass the exam, which can be described as surface or atomistic learning, rather than really engaging with the subject which can be described as deep or holistic learning [1]. Thermodynamics 2 is taught in the third year of the level 8 Honours B.E. in Mechanical Engineering in the University of Limerick (UL). Following background information about the module and where it occurs in the course, the development of assessment in this module over 3 years will be examined. This development was in the form of an introduction of assignments or, class questions, during lecture time. The number of class questions and the marks assigned to them was modified to make the learning experience more beneficial to the students. Analysis of the overall module grades shows how the introduction of class questions has increased the number of students attempting questions in the end of semester exam, and as a consequence has increased the overall grades.

INTRODUCTION
The Thermodynamics module is taught in the Spring semester of 3rd year to approximately 75 Mechanical Engineering students who have just returned from Co-operative Education (Co-op), a 6-7 month work experience. This has a large impact on the students and how they learn, as will be discussed in more detail. The pre-requisite module for this is Thermodynamics 1 and is taught in Autumn Semester of 2nd year. Table 1 presents a reduced course outline, highlighting these two modules, and these influence how the students approach learning in the module Thermodynamics 2.

As it has been over a year since the students completed the pre-requisite module, and they have been through the Spring semester of 2nd year and then Co-op, their retention of information can be questioned. Also, anecdotally, it has been found in the course that every year students tend to fare less well overall in Semester 6 (Spring 3rd year), with their Quality Credit Average (QCA) falling by an average of 0.2. The QCA is the method used in UL to summate the grades for modules, culminating with the degree being based on years 2 to 4. The highest QCA possible is 4.00, with a QCA of 2.00 (or equivalent of an average of a C3 grade) being necessary to graduate, or indeed proceed from year to year.

The author believes this drop in QCA is down to two reasons. Firstly, the students have been out of ‘study mode’ for an extended period of time. The second reason is that they tend to come back to college with savings from their earnings while on Co-op, and they tend to enjoy the social aspect of college life with this money, and then all of a sudden they are half-way through the semester with coursework deadlines looming, swiftly followed by exams. There are a
number of generalisations made here, but it holds true for the majority of the class. It is also important to note that there are six fairly complex engineering modules in this semester, all quite theoretically based, of which Thermodynamics 2 is but one.

<table>
<thead>
<tr>
<th>Year</th>
<th>Autumn Semester</th>
<th>Spring Semester</th>
<th>Summer</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Thermodynamics 1</td>
<td></td>
<td>Co-op</td>
</tr>
<tr>
<td>3</td>
<td>Co-operative Education</td>
<td>Thermodynamics 2</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

For the cognitive, humanistic and constructivist learning theories the importance of knowing the background to the student’s learning is key in being able to help them further this learning. In the context of a large group, such as this module is taught to, it can be difficult to know each student’s individual personality or stage of development, but it is possible to generally know where they are coming from in terms of their age and what has been covered already in the course (though one does not know whether or not they have learned it).

It is in this context that the author has tried to improve student performance through the introduction of in-class assessments, or class questions, over a two year period.

**RESOURCES AND METHODS**

*Teaching and Learning in Thermodynamics 2*

There are five sections to the module, each dealing with a different thermodynamics topic. There are three lectures each week, and for three weeks of semester there is a 2-hour laboratory, an experiment in 3 of the subject areas, and on the other weeks there is a 1-hour tutorial, seven in total, giving one for each topic and two more for revision. Even though the majority of the students are 20 years old, the approach to the module is very much subject-centred, not allowing the students to choose what they want to learn, which is what Knowles *et al.* [2] state should be the case for the adult learner in his theory of Andragogy.

The previous lecturer for this module produced a booklet of notes for the students which were photocopies of the theory he covered, hand written, and was available form the University Print Room. As the author questions the efficacy of hand written notes, a set of typed notes were produced for the Print Room, including all the tutorial question sheets and the laboratory exercises. A concern with supplying notes to students is that weaker students feel they no longer need to attend all lectures, not understanding that there can be added value in attending, if only to hear the information before they approach it prior to an exam. The author feels strongly that attendance at lectures is very valuable to the learning experience, but does feel it is important that students do not spend the lecture just taking notes as this does not allow them to engage with the work, which is an important factor in retention of information [3]. Also, generally students
capture less than 40% of lecture information in their notes [4]. The compromise taken is to supply the majority of the notes, with gaps left for students to fill in important figures and equations. Within Thermodynamics the figures or schematics used are a very important aspect in learning how to solve problems, and students need to know how to produce them for themselves.

The lectures are mainly didactic, with information being presented on PowerPoint, allowing students the time to fill in the notes when necessary. Prior to each tutorial sample questions are completed during lecture time, to get the student’s started with each tutorial sheet. When examples are being shown to the students, they are encouraged to attempt the solutions in steps as the questions are worked through. Again having to actually do something rather than just take down the solution should help with retention.

In general the tutorials associated with the Mechanical Engineering course are for smaller groups, up to maximum 30 students, are taught by research students and they have become nearly extensions to a lecture, with students just taking down the solutions to tutorial questions. Directly on becoming responsible for Thermodynamics 2, the aim was to try engage the students in the tutorials, asking them to attempt questions before they attended, and to treat the tutorial as a free ‘grind’, that they bring the problems they had in solving questions. The Tutorial Assistant (TA) was instructed to only answer questions, but that if it was evident that students hadn’t attempted questions, that he start solving one, but give them time to attempt the steps to the solution themselves. The experience over 3 years with this module (but also with other modules) has been that the majority of students still do not attempt questions, and indeed feedback has been that they are unhappy with this type of tutorial, preferring to do it the way they are used to, which is just be given the answers. There are always students who do attempt questions, and who obviously take a deep approach to their learning [1]. Therefore for a number of reasons, the majority of students in the course take a surface approach, or an atomistic approach rather than a holistic approach to their learning in the module. In order to change the students approach, changes were introduced to the assessment of the module which will be discussed in the next section.

While teaching the module for the second time a final year project was inititated to produce an online tutorial resource to allow students, who were not engaging in the classroom, another route to engage with the work. This project focussed on the first two topics, and presented sample questions in a step-by-step manner to encourage a student to work through questions. The following year a follow-on final year project extended the web resource to another two topics. While it cannot quantitatively be stated how this affected the student’s learning, anecdotally some students did find it useful, but again there are still a body of students who don’t seem to engage unless they have to, such as when there is an assessment due. According to Prosser and Trigwell [5] these are ‘disintegrated’ students, who appear not to know what it means to learn or how to go about learning. Trying to reach these students is an ongoing challenge, and isn’t one that will be solved in the short-term with a ‘quick-fix’.

A final interesting note to teaching and learning in this module is that there is a field trip, about a third of the way through the semester, to Moneypoint Power Station in Co. Clare. This is the only field trip that is organised for the students throughout their four years of study, and they are brought on a tour of the coal-fired steam cycle power generation station, which is a topic they have just completed in the module. The aim of this field trip is to put in perspective the ‘dry’
theory they are trying to learn. In numerous end of year surveys graduating students have said that this trip is one of the highlights of their studies, but it must be noted that along with the learning outcome, this may be due to the rest stop in a well-known hostelry on the way home.

Assessment in Thermodynamics 2

Ramsden (2003) states that ‘University teachers frequently assess as amateurs when the task demands grave professionalism’ and describes a view of teaching as a transmission of knowledge, where assessment follows learning. The majority educators in engineering would subscribe to this view and employ summative assessment methods at the end of the semester and bemoan the fact that their student’s don’t seem to learn. Formative assessment, with correctly administered feedback should be an integral part of the learning process, helping students to reflect upon their learning [1, 6]. It is important to note that student’s perceptions of what will be examined will have an impact upon how they learn [1, 7]. While approaches to learning have moved in the direction of constructivism, approaches to assessment have remained inappropriately focussed on testing, reflecting behaviourist theories [8]. The main development to the module has been in the way it is assessed, as the author believes assessment is a main part of teaching and learning.

The module had been assessed using an exam worth 80% of the overall grade, with coursework based on the laboratory work worth 20%. In the exam there is a question per section of the course giving a total of 5 questions, of which the students should attempt 4. This type of exam can encourage a surface approach to learning, with the students memorising questions from only some of the topics and not learning how to use the methods employed [1].

On first teaching the module, in 2005, it was decided not to make any changes to the assessment. Instead this first year the effort was made to engage students in the lectures and tutorials, and with the notes used, and it seemed the students had a good grasp of the subject. However while lecture attendance was reasonable, tutorial attendance was poor, and the ensuing grades were not good with a class average QCA of 1.96, less than a passing grade. It was noticed that the uptake on Sections 1 & 2 was low, so something was needed to encourage the students to start working earlier.

In 2006, the second time the module was taught, two ‘Class Questions’ were introduced, on Sections 1 and 2 and worth just 2.5% each, leaving the exam mark the same at 80% and reducing the coursework (laboratory report) contribution to 15%. The class questions took place in Week 6 & 8 of semester, during half a lecture slot, were open book, and based on tutorial questions. When the corrected questions were being returned to the students half a class was spent working through the question to allow them to see where they may have gone wrong. It did mean an increase in module grading workload, but it resulted in a more balanced continuous assessment. Another benefit of the class questions is that it highlights to the student where they went wrong, as they receive feedback, which Yorke maintains should allow them to enhance their learning [6].

Following a focus group in 2007, with 4 students from the 2006 class, this approach was extended to 4 questions, in Weeks 4, 7, 11 & 13; based on Sections 1, 2, 4, 5. Each question was now worth 5%, with the coursework lab report worth 20% and the exam grade reduced to 60%. Preliminary results are shown in the next section.
RESULTS
As the changes to module assessment were made to improve student learning, rather than being instigated as a specific action research project, the focus wasn’t on obtaining results to prove that it worked. However, a number of interesting trends are shown here.

While it is important to note that lecture attendance in 2006 was better than the previous year anecdotal evidence showed that the class questions had prompted earlier study, and this bore through with the final grades, with the class average QCA increasing to 2.08. It also changed the number of students who attempted the exam questions on Sections 1 & 2. As can be seen in Figure 1 and Table 2, there was an increase in numbers attempting questions in section 1 & 2, but this came with a decrease in numbers attempting questions in Sections 4 & 5.

Again in 2007 class average the QCA increased, this time to a significant 2.63. Table 2 shows that while there was a decrease in numbers attempting Question 1, the number attempting Question 2 increased slightly with a significant increase in those attempting Questions 4 & 5. As can be seen Section 3 is the one which is attempted by most students, and is seen to be the most straightforward, which is why there hasn’t been a focus on introducing a Class Question in that topic.

Figure 1: Numbers of students attempting exam questions over a three-year period

Table 2: Numbers of students attempting exam questions (students were asked to do 4 of 5 questions)

<table>
<thead>
<tr>
<th></th>
<th>Q1</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5</th>
</tr>
</thead>
<tbody>
<tr>
<td>% attempted Q1</td>
<td>78%</td>
<td>55%</td>
<td>96%</td>
<td>65%</td>
<td>68%</td>
</tr>
<tr>
<td>% attempted Q2</td>
<td>85%</td>
<td>86%</td>
<td>92%</td>
<td>56%</td>
<td>53%</td>
</tr>
<tr>
<td>% attempted Q3</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% attempted Q4</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>% attempted Q5</td>
<td></td>
<td></td>
<td></td>
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<td></td>
</tr>
</tbody>
</table>

Change in 2006

<table>
<thead>
<tr>
<th></th>
<th>8%</th>
<th>56%</th>
<th>-4%</th>
<th>-14%</th>
<th>-23%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Change in 2007</td>
<td>-13%</td>
<td>3%</td>
<td>-3%</td>
<td>28%</td>
<td>42%</td>
</tr>
</tbody>
</table>

Change in 2007
DISCUSSION AND CONCLUSIONS

To summarise, this way of incentivising students to complete revision earlier in the semester seems to pay off, and the impression from talking with students, and from Formative Teaching Evaluation, is that when exam time comes Thermodynamics 2 is one of the subjects they feel happy about as they have been studying all along. The student perceives that they are being awarded for this work, and as described by Wakeford [7] this impacts on their learning behaviour. They have also received feedback about where they may be going wrong when trying to solve problems, which also helps with their learning.

In moving forward the allocation of marks will be changed so that there will be a shift away from the end of semester exam, with the aspiration that the Class Questions will change from in-class exams to a more problem based learning assessment.

REFERENCES

REAL-WORLD PROCESS DESIGN FOR MECHANICAL ENGINEERING STUDENTS: A CASE STUDY OF PBL IN DIT

Kevin Delaney and John Kelleher

Department of Mechanical Engineering, Dublin Institute of Technology
E-mail: Kevin.Delaney@dit.ie

ABSTRACT

Engineering education deals primarily with calculating quantitative performance of engineering objects, such as machines, circuits or dams, and with designing variations of these objects. However when engineering graduates enter the workforce they must be able to do a great deal more than solve the technical problems taught in engineering school [1]. More specifically they will need to deal with a great range of problems some of which are not technical engineering problems at all. Examples of such problems include working as part of a larger group, project management, negotiation, component sourcing and an awareness of the multi-disciplinary nature of engineering. Such real-world engineering problems force graduate engineers to draw on their professional and personal resourcefulness, adapt to on-the-job pressure, cope with people problems and broaden their knowledge base. Increased competition and high labour costs put pressure on engineering graduates to contribute to companies as soon as they enter the workplace and reduces the time available to graduates to develop these skills on-the-job. To help students develop real-world engineering skills as part of their engineering education the Mechanical Engineering Department in Dublin Institute of Technology (DIT) three years ago introduced Problem Based Learning (PBL). This paper describes a PBL module for Third Year Mechanical Engineering students at DIT designed to help students refine their soft skills in addition to a deeper understanding of their technical skills. This approach, developed by Kelleher, gives students the opportunity to develop a range of experiences which will prepare them to contribute to their employer on entry to the company.

INTRODUCTION

Graduate engineers of the future must be capable of (1) working and learning as part of a team, (2) communicating their ideas and requirements effectively through presentations, and (3) negotiating to find the optimum solution to the problem they are working on [1]. Companies want graduate engineers who can perform from day one. To meet this expectation student engineers should be given the opportunity to develop such skills during their professional preparation. In most DIT engineering programs students typically work on clearly-defined projects as individuals or in groups of three or four in the early years of their formal engineering education. Such projects allow students to work as part of a small team. Students can develop and refine their soft skills but do not get an opportunity to evaluate their knowledge or understanding in the context of larger groups. To promote deep learning, where students get experience of working as part of a larger group, the Third Year Mechanical Design Projects in DIT are arranged in the form of PBL exercises. The course was developed by Kelleher and has operated in the form described herein for the last 3 years.
PBL presents students with a real-world problem and students explore various solutions in a self-learning capacity before proposing an appropriate solution. This approach to learning, where a problem is posed to drive the learning, was introduced by the McMaster Medical School in the 1960s. Because the medical students typically worked in groups of 5 or 6 students the approach is often called small group PBL. The model described in this case study involves larger groups of between 25 and 30 students and is often referred to as large group PBL.

PBL has now become a widespread teaching method in many professional fields, particularly in disciplines where students must learn to apply knowledge not just acquire it [2]. PBL is grounded in a constructivist theory of learning and is based on the premise that learners come to know something new, not by passively hearing it, but by actively engaging with it and connecting it to what they already know. The philosophy of PBL is to build and support a learning process established around engineering problem solving. In this case students learn by conducting a relatively complex mechanical engineering design project under the supervision of lecturers who act as coaches and facilitators.

THE PBL COURSE STRUCTURE

Third Year Mechanical Engineering students in DIT are split into class groups of between 25 and 30. To really engage the students and to make the project as relevant as possible for each group, students select a project under the supervision of the lecturers involved. A brainstorming session, where the students propose several different projects, is used to generate a list of potential projects. All of these are considered in turn by the full class and the lecturers before the students vote for one. The chosen project, which should relate to the mass production of a consumer product, must involve different mechanical engineering areas which the students have already encountered. This enables students to apply and gain a deep understanding of how various mechanical engineering topics integrate. However the problem must highlight for students the need to learn new knowledge before they can solve the problem. For the purpose of the project the lecturers act in the role of clients. The projects selected by the two student groups in 2007/08 were to define, design, specify and source the components needed for production equipment to (1) assemble a ball-point pen and (2) to package bulk jam into 454g pots.

The objective of the design project is to give students the opportunity to manage and deliver a real-world project under simulated industrial conditions. To make the experience more realistic students must overcome challenges of working and liaising as part of a larger group. In so doing students are exposed to a range of challenges experienced by engineers in industry settings. With guidance from the facilitators students are expected to take full responsibility for managing the project and deliver an appropriate solution.

Students have 12 formal sessions of 3 hours duration each over a six-week period and are expected to use these sessions to review and plan their work to ensure that they can meet the relevant project milestones. An overview of the milestones in addition to a generalized list of tasks, and the allowed duration of each task, is shown in Figure 1. Formal deliverables for the course are (1) a preliminary report, (2) a final report and (3) a final presentation in front of a board of assessors. Every student is
expected to present the elements of the design which they developed and be able to answer questions about any aspect of the project. This encourages a sense of shared ownership and responsibility for the project in addition to ensuring that all students engage in and benefit from the learning process.

During the initial sessions students are encouraged to define project objectives. The definition stage involves students developing a design brief to focus their design. This typically involves detailing the dimensions and materials of all components, the required production rate, the viscosity of any liquids involved, legislation to be complied with and any other requirements in terms of packaging, etc. Students then develop an initial, high-level concept for the production machine which is typically in the form of a preliminary process flow. Students are expected to focus on key process steps and develop a machine concept around that. Students are encouraged to use sketches and simple calculations to evaluate their designs. This enables students to quickly analyse the practicality of their design, and practice in performing preliminary calculations.

With the process concept selected all students are divided into sub-groups. Each sub-group is responsible for a specific stage of the project. The number of sub-groups created is based on the number of stages required to satisfy the process concept. The project definition, process concept and task allocation forms the preliminary project report. This obliges students to commit to doing specific tasks within a specific timeframe and forms part of the formal project assessment.

Table 1 lists typical job titles and primary responsibilities for each sub-group. The number of students assigned to each task is proportional to the predicted workload. The detailed design function is the largest group of students. These students are expected to create CAD models of the assembly machine based on dimensions justified by calculations. To encourage students to use standard components where possible the sourcing group is expected to find available components which satisfy these requirements. The dimensions for components selected are fed back to the design group to be incorporated into the CAD model. Experience of such an iterative process gives students confidence and is important in educating engineers about the importance of multidisciplinary teams.

A single student is assigned the task of researching the applicable legislation to ensure that the final machine will comply with it. This typically includes ensuring that the correct materials are specified where specific requirements exist and that safety guards, switches and waterproof components, etc are incorporated into the machine design. This highlights the importance of CE marking on
machines to be manufactured or operated within Europe. The machine programming function is normally handled by a single student. Pseudo-code is developed to encourage the students to consider machine timing, or sequencing, as part of the overall design process.

<table>
<thead>
<tr>
<th>Title</th>
<th>Approximate number of students</th>
<th>Primary responsibilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>Project manager</td>
<td>1</td>
<td>Responsibility for co-ordination of work and report editor</td>
</tr>
<tr>
<td>Detailed designers</td>
<td>20</td>
<td>To fully detail the design for each stage of the process. Design groups are created to work on each stage.</td>
</tr>
<tr>
<td>Machine programmer</td>
<td>1</td>
<td>To develop code to operate/sequence the machine</td>
</tr>
<tr>
<td>Legislation</td>
<td>1</td>
<td>Ensure that relevant legislation, particularly health and safety is being complied with.</td>
</tr>
<tr>
<td>Component sourcing</td>
<td>3</td>
<td>To find suppliers of components specified (and encourage use of standard components where feasible).</td>
</tr>
</tbody>
</table>

*Table 1: Typical job titles and primary responsibilities for each team member.*

**ASSESSMENT**

As already described the formal deliverables for the course are (1) a preliminary report, (2) a final report and (3) a final presentation in front of a board of assessors. The reports must clearly indicate the responsibilities of each individual involved. Assessment and relevant feedback is important for the students. The assessment of group PBL projects is a challenge, particularly where the contribution of each student must be graded. Co-operative learning, where students work together to learn, as opposed to competing with each other for marks is the ideal and some challenges have been reported in helping students understand the importance of co-operation [3]. A group-mark for the entire project team might be a disadvantage to the stronger or more committed students and might also be abused by weaker students who might assume a passive role in the project. To alleviate this problem the authors implement a combined team and individual assessment. Based on a review of the interim and final reports in addition to the formal presentation the same grade is awarded to all students in each group by the board of assessors. This board of assessors includes the Head of Department and the lecturers involved. The deliverables are assessed to evaluate how the students have managed to meet the specified module learning outcomes. The task allocation list together with observations made during the formal project sessions are then used to adjust the mark for each student based on their individual contribution to the successful outcome of the project. The marks may be adjusted either upwards or downwards, based on this assessment.

**DISCUSSION**

Some sub-groups were nervous about accepting students who they felt would not attend the tutorial sessions. In the case of one group, students who missed the initial classes were assigned to a non-essential task of final packaging. This action was taken due to the students’ concern that they would get a reduced mark if they had a non-committed member in their team. This sidelining had the effect
that the students involved developed an exemplary attendance record for the remainder of the project and made a substantial contribution to the overall success of the project. Some students were reluctant to make decisions since they are afraid of being “incorrect”. This probably comes from an expectation that there is a right or a wrong answer for everything. The design problems posed have many solutions and, being an iterative process, the students are encouraged to refine their concept and justify the chosen solution. To encourage the students to think the process is emphasized above the product. It is important that students learn to justify their decisions since it is an important ability for engineers to develop.

Students find it very hard to plan and integrate their activities as part of a larger group. A number of sub-groups, particularly the CAD, machine programming and component sourcing groups, complained that they did not receive the information they needed to complete their task in a timely fashion. When this delay was communicated to the full group it highlighted the importance of time and project management for the success of the entire project.

From the experience of running this project over a number of years in the Department of Mechanical Engineering, it is clear that the student project manager chosen to run the project has a significant influence on the overall success of the project. Based on previous experience of the class group and observations of likely candidates during initial brainstorming sessions lecturers may have opinions regarding the most suitable candidate and the expectations on what (s)he must do are clearly outlined to the class group. However the students select their own project manager and must live with the consequences. The project manager also serves as the editor for the final report. It is a challenging and demanding role since (s)he must continuously push and cajole their “colleagues”, who in reality are classmates, to meet the relevant deadlines. It has been proposed by a number of students that the effectiveness of the project manager could be increased by allowing them to assign a certain proportion of the marks. Such self-assessment has been reported as an element of other PBL studies [3]. However the adoption of such an approach has not been seriously considered to date since it is felt that it may result in conflict within the class group.

**CONCLUDING REMARKS**

The authors believe large-group PBL in DIT offers many potential benefits to students, lecturers and ultimately industry. In addition to the engineering skills learned, applied and refined by the students during the project other potential benefits are summarized in the Table 2. Students benefit from the opportunity to develop project management, presentation and negotiation skills, in addition to an increased awareness of component sourcing and the multi-disciplinary nature of mechanical engineering and are better prepared for embarking on their final year projects. Lecturers benefit from working with more motivated students who can actually apply theory in a practical way. Potential benefits for industry are easier assimilation of students into the workplace since the students have increased experience of working as part of a larger team. The project increases students’ confidence resulting in more resourceful, motivated students who can be easily assimilated into workplace teams. Students have expressed their enjoyment of the course despite the amount of work involved and commented that they felt the course prepared them well for final year projects, particularly in terms of project management and presentation skills.
The projects are time consuming for both students and lecturers. Any issues that arise in the simulated industrial environment must be addressed by the course facilitators.

As highlighted by Harris and Briscoe-Andrews program evaluation is important to understand if the course is effective in achieving desired learning outcomes [4]. Evaluating is difficult since (1) the lead-time for students to enter the workplace delays a formal response from industry, (2) students’ lack of experience of alternative learning methods may affect student objectivity in conducting a student evaluation and (3) the absence of a control group may affect the interpretation of any results obtained. No formal evaluation specific to this module has been conducted to date. However as course participants have now graduated and are working in industry a formal evaluation is planned to evaluate the benefits and drawbacks for all stakeholders.

<table>
<thead>
<tr>
<th>Potential benefits of large-group Problem-Based-Learning</th>
<th>For Students</th>
<th>For Lecturers and DIT</th>
<th>For Industry</th>
</tr>
</thead>
<tbody>
<tr>
<td>Acquire and develop project management, presentation and negotiation skills</td>
<td>Motivates students to take more interest in mechanical engineering</td>
<td>Easier assimilation of students into the workplace</td>
<td></td>
</tr>
<tr>
<td>Better-prepared for final year project</td>
<td>Provides a more authentic assessment tool</td>
<td>Experience of working in a team environment</td>
<td></td>
</tr>
<tr>
<td>Suits learners who like continuous assessment (rather than single end-of-year exam)</td>
<td>Allows students to apply theory in a practical way</td>
<td>Resourceful, self-motivated students</td>
<td></td>
</tr>
<tr>
<td>Increased awareness of the role of sourcing components/sourcing in mechanical engineering</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Greater sense of satisfaction and comprehension of the multi-disciplinary nature of mechanical engineering</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 2: Potential benefits of large-group Problem Based Learning.

REFERENCES
LEARNING STYLES OF FIRST YEAR LEVEL 7 ELECTRICAL AND MECHANICAL ENGINEERING STUDENTS AT DIT

Aidan O'Dwyer

School of Electrical Engineering Systems, Dublin Institute of Technology, Dublin
E-mail: aidan.odwyer@dit.ie

ABSTRACT
This paper investigates the learning styles of first year, Level 7, mechanical and electrical engineering students at DIT, using the index of learning styles survey as developed by Felder and Soloman [1]. Student learning styles on these programmes are compared with the results from other such surveys. The correlation between student performance and their individual learning styles is examined in outline. Knowledge of the strongly visual learning style of these cohorts of students may be used to improve the learning environment.

INTRODUCTION
In a seminal paper, Felder [2] suggested that engineering students (in particular) have four dimensions to their learning styles. Each of the dimensions is described in opposite terms (active versus reflective, sensing versus intuitive, visual versus verbal and sequential versus global). In summary, active learners learn by trying things out or working with others, while reflective learners learn by thinking things through or working alone; sensing learners are oriented towards facts and procedures, while intuitive learners are oriented towards theories; visual learners prefer visual representation of presented material, while verbal learners prefer written or spoken explanations; sequential learners learn in incremental steps, while global learners are systems thinkers who learn in large leaps. Felder measures student learning styles by means of an Index of Learning Styles (ILS) on-line survey [1], composed of 44 multiple-choice questions, with two possible answers for each question. In a series of papers, Felder and co-workers (e.g. [3]-[5]) suggested that most engineering students are active, sensing, visual and sequential learners.

A considerable number of studies have been performed using the ILS questionnaire, both in Ireland (e.g. [6]-[9]) and internationally (e.g. [5], [10]-[12]). This paper will focus on the learning styles of first year Level 7 engineering students and will examine, in outline, the correlation between first year engineering student performance and their individual learning styles. Broadly similar work has previously been done at IT Tallaght [7].

The two Level 7 student cohorts surveyed, in the 2007-8 academic year, were from the DT009/DT016 electrical engineering Level 7 programme and the DT006 mechanical engineering Level 7 programme. In both cases, the on-line ILS survey form was printed out, distributed to the students for completion in week 1 of the course and the survey results were collated by the author. A summary of the results, with explanations, and how the average results would inform the author’s subject teaching in the semester was provided to the students in week 2 of the course; in addition, each student received their own individual survey result. Of the 41 DT009/DT016 class group, 35 completed the survey form; of the 47 DT006 class group, 35 also completed the survey form, giving an overall response rate of 80%. It should be mentioned that
student participation was voluntary, with no student exposure to any risks or reprisals for refusing to participate (as in the study performed by Zywno [12]).

ANALYSIS

The data was analysed and the learning style preferences (in percentages) are recorded in Table 1 for the two student cohorts surveyed. Table 1 also shows data from comparable student cohorts. The table structure is similar to that used in a table by Felder and Spurlin [5], with A, S, Vs, Sq and N standing for Active, Sensing, Visual, Sequential and Number (of students), respectively. Thus, for example, of the 35 DT009/DT016 students who completed the survey, 69% were classed as active learners (and by implication 31% were classed as reflective learners), 77% were sensing learners (so that 23% were intuitive learners), and so on.

Table 1: Reported learning style preference in percentages (following Felder and Spurlin, 2005)

<table>
<thead>
<tr>
<th>Sampled Population</th>
<th>A</th>
<th>S</th>
<th>Vs</th>
<th>Sq</th>
<th>N</th>
</tr>
</thead>
<tbody>
<tr>
<td>DT009/DT016, Level 7, Year 1, 2007-8</td>
<td>69%</td>
<td>77%</td>
<td>94%</td>
<td>71%</td>
<td>35</td>
</tr>
<tr>
<td>DT006, Level 7, Year 1, 2007-8</td>
<td>66%</td>
<td>57%</td>
<td>97%</td>
<td>60%</td>
<td>35</td>
</tr>
<tr>
<td>IT Tallaght, Level 7, Year 1 [7], 2002-3</td>
<td>81%</td>
<td>63%</td>
<td>85%</td>
<td>29%</td>
<td>-</td>
</tr>
<tr>
<td>IT Tallaght, Level 7, Year 1 [7], 2003-4</td>
<td>78%</td>
<td>52%</td>
<td>88%</td>
<td>26%</td>
<td>-</td>
</tr>
<tr>
<td>IT Tallaght, Level 7, Year 1 [7], 2004-5</td>
<td>69%</td>
<td>67%</td>
<td>76%</td>
<td>37%</td>
<td>-</td>
</tr>
<tr>
<td>Second Level Students. Mean age 16.4.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Studying Engineering for the Leaving Cert [6].</td>
<td>70%</td>
<td>79%</td>
<td>91%</td>
<td>58%</td>
<td>163</td>
</tr>
</tbody>
</table>

The DIT student cohort results, as revealed by this table in broad terms, are clearly compatible with other such results and with Felder’s conclusions, mentioned previously, that most engineering students are sensing, visual, active and sequential learners.

More detailed analysis of the data is shown in Figures 1 to 4, in which strengths of the reported preferences are indicated. Having completed the survey, each learner is assigned a point on the scale from –11 to +11 for a given dimension. For example, in the active-reflective dimension, a learner scoring –11 is a strongly active learner, with a learner scoring –1 being a marginally active learner. Clearly, a large percentage of students have no significant preferences, except for the Visual-Verbal category, for which a large majority of students have a moderate or strong preference for visual learning. Particularly interestingly, the majority of students show no strong preference for active learning; traditionally, Level 7 programmes place particular stress on active learning in laboratories and workshops.
Figure 1: Active versus reflective learners – DT009/016, DT006 Year 1 students

Figure 2: Sensory versus intuitive learners – DT009/016, DT006 Year 1 students
Figure 3: Visual versus verbal learners – DT009/016, DT006 Year 1 students

Figure 4: Sequential versus global learners – DT009/016, DT006 Year 1 students
CORRELATION BETWEEN STUDENT PERFORMANCE AND INDIVIDUAL LEARNING STYLE

At the time of writing, only outline results can be reported, as full assessment results for the academic year are not yet available. Results are reported for the Electrical Systems subject on the DT009/DT016 programme, for which the author has academic responsibility. This subject, in common with many first-year subjects in programmes with Level 7 awards, is knowledge or fact-based. It is a central technical subject in the programme, and learning in the subject is progressed further in the remaining two years of the programme. The subject is divided into two thirteen-week modules; in each module, students attend two hours of lectures and two hours of laboratories in the subject each week. The subject is assessed in the following manner:

- Terminal examination (50% of subject mark), held after the completion of the second module. This examination has a compulsory question and five other questions, three of which are to be attempted. Two of these five questions are in multiple-choice format.
- Laboratory work (25% of the subject mark); this is assessed continuously.
- Individual student project work (12.5% of the subject mark), assessed halfway through the second module.
- Module 1 assessment (12.5% of the subject mark); in 2006-7, this was an exclusively multiple-choice examination, held after the completion of the first module.

The results of the ILS survey informed instruction in the subject in the 2007-8 academic year. Lecturing was done using PowerPoint, with extensive visual material employed. Lectures are also made available on the WebCT online environment. This is partly because attendance at lectures is unsatisfactory; in addition, the subject was followed by a significant number of part-time students. Active learning in the lecture environment was prioritised, with approximately 35% of the lecture time devoted to student problem solving exercises, with the aim of increasing the depth of knowledge of the material. In addition, the module 1 assessment and the terminal examination were changed to incorporate more visual components in the questions.

Of the twenty-seven students whose assessment results may be directly correlated to their ILS survey results, 5 did not pass the examination; 3 of these had a −11 or −9 preference for visual learning. Sixteen students did not pass the module 1 assessment; 7 had a −11 or −9 preference for visual learning, and 2 more had a −11 preference for sensing learning. Six students dropped out during the year; 2 of these students had a −11 or −9 preference for visual learning, and 1 more had a −11 preference for sensing learning. Generally, students who performed well on all aspects of the assessment have no strong preferences for a particular type of learning, though there are individual exceptions. It is important to report that the changes to lecturing method and assessment mentioned, as a result of the ILS survey data gathered, has helped to increase the overall student success rate after the first-sitting assessments are completed from 52% in the 2006-7 academic year to 68% in the 2007-8 academic year.

CONCLUSIONS AND FUTURE WORK

The index of learning styles survey is a useful tool to identify the most preferred student learning mode, for both student and lecturer. It provides rapid feedback and allows the lecturer to tailor, to some extent, both teaching techniques and assessments to the clear visual learning preference that is evident from the survey results. Such tailoring allows improvement in the student retention rate. In future work, the author will evaluate more completely the relationship between
assessment results and student learning style. Even on the basis of the outline work, it is clear that students at risk of not progressing in their programme tend to have an extreme learning style preference; the identification of such students at the start of their college career allows focused intervention to be considered. It would be desirable to create an overall learning environment across all subjects to appeal to as wide a range of learning styles as possible.

REFERENCES
Project, Laboratory, and Problem Based Learning
A PROJECT BASED APPROACH TO LEARNING FOR 1ST YEAR ENGINEERING STUDENTS

Brian Corcoran¹ and John Whelan²

¹School of Mechanical and Manufacturing Engineering, Dublin City University
²School of Electronic Engineering, Dublin City University
E-mail: Brian.Corcoran@dcu.ie

ABSTRACT
Support for transition from Leaving Certificate and entry to college for 1st year engineering students can be difficult to achieve. This new course offers an innovative project based approach to learning for 1st years with an introduction to design to build confidence in student ability and give motivation in research and discovery skills. The project takes place in small groups and relies heavily on presentation, group and individual skills. The Mechanical and Manufacturing and the Electronic Engineering Schools at Dublin City University offered this new module for all first year Engineering Students in 2006. The course entitled, ‘Project and Laboratory Skills’ was an immediate success with increased participation and retention rates and a high level of academic success in assessment. This paper highlights the overall module concepts, teaching and learning outcomes and the resources required for such a module.

INTRODUCTION
1st year students must adapt quickly to university and develop a range of new professional and personal skills while adapting to unfamiliar surroundings and campus life. A number of institutions have introduced 1st year / freshman modules to assist with this transition [1, 2, 5]. Others have examined the needs of the engineering profession into the future and in particular the education standards required to meet these needs [4]. Project based learning has been highlighted as a key component in the transition of 1st year students to university based engineering degree courses [3]. A new module in the faculty of Engineering and Computing at DCU aims to support students in this transition while honing their skills in design, manufacture, assemble and presentation. The department is fortunate to have highly skilled technical, academic and support staff and a world class engineering workshop at its disposal. Students are encouraged to interact with staff through mentor meetings, weekly scheduled classes and informal meetings. They are also encouraged to problem solve for themselves and in groups and to design, simplify and modify their concepts through formal feedback. The class is taught and assessed in a number of ways to promote both individual contribution and team work. The bulk of this assessment is in groups of 4 which aids team work and presentation skills. Within 2 semesters each team must design and build a robot to compete in a soccer competition. Some of the design constraints and the parts supplied are outlined in table 1.
<table>
<thead>
<tr>
<th>Design constraints</th>
<th>Parts List</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robot size limited to A4</td>
<td>RC receiver</td>
</tr>
<tr>
<td>Only parts supplied to the group can be used (tools, materials and mechanical/electronic parts)</td>
<td>Servo (2 required) steering/cupping ball</td>
</tr>
<tr>
<td>Pitch size will be 4m * 3m</td>
<td>Solenoid for kicking ball</td>
</tr>
<tr>
<td>Ball size will be that of a golf ball</td>
<td>Various Components and Material</td>
</tr>
<tr>
<td></td>
<td>Motor Speed Controller</td>
</tr>
</tbody>
</table>

Table 1: Project Design Constraints and Project Parts lists

PROJECT STRUCTURE AND ASSESSMENT
The class (currently 120 students), is divided into teams of 4 and these teams cycle through a range of activities in semester 1 and 2. These activities are timed to impart specific skill sets at various points throughout the semester to aid completion of the project in week 10 of the second semester. The activities include the following

Semester 1 structure and events

1. Mechanical Workshop Skills (Weeks 1-6): Each student has to manufacture a metal aeroplane from a given set of detailed drawings. The aim of this task is to introduce students to a range of workshop skills including reading of engineering drawings, marking up of engineering components, drilling, cutting, filing and tapping of parts and assembly of finished components. This is an individual task and the students are assessed on their ability to manufacture to specific guidelines, ability to manage their time and of course the finished product. Support and feedback from academic and technical staff is offered along the way and formal assessment and marks give in week 6.

2. Mechanical Drawing (weeks 1-12): Through the entire first semester students are required to attend formal studio work related to drawing of engineering components. These are 3 hour drawing classes per week and introduce student to the art of graphical communication. A deliberate decision was taken to exclude the use of CAD packages in the 1st semester to encourage students to develop manual drafting skills and to develop accuracy and neatness in relation to drawing presentation. This drawing course is then backed up with CAD software in the second semester when student realise the effort required to product a quality engineering drawing.

3. Electronic Design (weeks 7-12): Following completion of the workshop skills course in week 6 students move on to a range of electronic’s skills classes. These include soldering, PCB board assembly and E-CAD labs for circuit design. Each of these courses last two weeks and result in students designing, building and testing electronic circuits.

4. Labs, Lectures and Presentations (weeks 1-12). Throughout the first semester students are required to attend labs sessions (including materials labs, electronic labs and drawing classes as mentioned above). They are also given lectures on design, concept development and presentation.
skills. Concepts for their design project (in this case a robot to compete in a soccer competition) are assessed in week 6 and three concepts are encouraged for this formal presentation. Feedback is offered on the concepts and students are encouraged to modify their final design before proceeding to develop detailed drawings of this final design by the end of semester 1.

Figure 1: Semester 2 Robot Build    Figure 2: Poster Presentation

Semester 2 structure and events:

1. Build Phase (weeks 1-10). During this build phase students must build their final design selected from a number of concepts presented during semester 1. The team work from detailed drawings and must devise a work plan and assign tasks to various members of the team. Technical support and guidance is offered throughout this build phase which take place in a well equipped engineering workshop (Figure 1).

2. Labs, Lectures and Presentations (weeks 1-12). The build phase is backed up with a series of labs (including thermo-fluids, electronic fundamentals and mechanics). A lecture slot is included in the timetable to allow course coordinators to address the class as a whole when required. Formal lectures are also given on design and assembly methods, electronics and on topics such as recycling, ethics and sustainable design. Each team is required to design a poster for a presentation of their work to the public in week 10 (Figure 2). These presentations take place in the foyer of the engineering building to encourage questions for a diverse audience.

3. Event and Assessment (week 10-12). Each team must compete in a soccer match in week 11. The first part of this event assesses how well each individual design functions. A golf ball is places in 5 strategic positions on a custom built football pitch. The team must demonstrate that their design can manoeuvre to the ball, cup it move towards the goal and kick the ball to score. The team has 3 minutes to score 5 goals. Once each team has demonstrated the functionality of their device the competition begins (Figure 3). Two teams compete in a soccer match for 5 minutes. Teams are eliminated on a knock out basis until the final two teams remaining compete for the overall title. Each team must complete a final project report and this is handed in during week 12.
TEACHING AND ASSESSMENT

No formal exam takes place in this module although a number of assessments and assignments must be completed. These include completed workshop projects, poster and presentation assignments and a final team report. The class is addressed as a whole at the beginning of each activity and also attend scheduled lectures. There is also considerable staff input through informal group discussions. Feedback is given in a timely manner and this encourages a good working relationship between staff and students. A web site has also been developed for this module where class material, timetables, archive material, photos of previous events, poster templates etc are available for students to used throughout the course of the module. Assessment of semester two is based on attendance, presentation skills, poster design, goals scored, a detailed engineering evaluation of the final device and the final project report. A break down of the assessment marks for semester 1 and 2 is given in Table 2.

<table>
<thead>
<tr>
<th>Semester 1 Marks</th>
<th>Semester 2 Marks</th>
</tr>
</thead>
<tbody>
<tr>
<td>Plane Fabrication</td>
<td>10</td>
</tr>
<tr>
<td>Design and Build Quality</td>
<td>30</td>
</tr>
</tbody>
</table>
Table 2: Assessment marks for semester 1 and 2.

<table>
<thead>
<tr>
<th>Concepts Presentation</th>
<th>10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speed Control Board</td>
<td>5</td>
</tr>
<tr>
<td>Poster and Goals Scores</td>
<td>15</td>
</tr>
<tr>
<td>Final Report</td>
<td>30</td>
</tr>
</tbody>
</table>

An issue highlighted regularly with group work is that of passengers and early dropouts within the group. This issue is addressed using attendance sheets, group mentors, staff feedback to module coordinators and student feedback. The objective is to highlight lack of attendance as early as possible and to initiate mentor/staff intervention at an early stage. Lack of contribution within any group is not tolerated and groups are encouraged to device workplans for each group member. Self regulation of the group is encouraged over staff intervention. However, if required, mentors and staff will intervene.

The level of participation, team work and general enjoyment and competition within this module is exceptional. Staff regularly comments on their under-estimation of student’s ability and the interest in problem solving and a high level of engagement within this module. Students do not see this module as a ‘just to pass the exam module’. They can work towards a given goal with limited information and an opportunity to learn, play and express themselves within there work. They can explore different ideas and designs and have the ability to show case their work to a wide audience. Group work encouraged early in the 1st semester forges life long relationships and has resulted in high success rates in this module.

The learning outcomes achieved on completion of this module include:

1. The solving of practical engineering problems using basic scientific knowledge
2. The use computer packages to write technical reports, create spreadsheets, make presentations and publish work
3. Use computer aided design (CAD) applications to create engineering drawings.
4. Use IT skills and software for learning, sourcing and presentation of material.
5. The ability to plan and complete a project on time.
6. The ability to work effectively within a team to achieve a desired objective

**RESOURCES AND LOGISTICS**

Initial set up costs for this module required that a new workshop area be designed and equipped in the school of electronic engineering and that an old workshop facility in the school of mechanical and manufacturing engineering be reequipped to facilitate this new module. However once this initial expenditure on tooling was spend in year one limited reequipping of each facility was subsequently required. The same was true of initial purchases of kits for the robot build as a number of components can be reused on a yearly basis. The overall cost of tools and kits for year one was of the order of €15,000 to accommodate 120 students.
The structure of this module required substantial staff student interaction. This includes module coordinators, academic staff, technical staff and group mentors. This contact time with students cannot be overemphasised as it can be the difference between success and failure in this module. To achieve this complex timetabling must accommodate staff interaction, lab time, mentor slots, presentations, group assessments and workshop time. It must also facilitate student and staff availability across two engineering schools. Scheduling of events, assessments and deadlines resulted in the need to develop a dedicated web site for this module which allows students to be informed of changes to timetables, groups, assessment dates etc on a daily basis.

Space lab and equipment requirements are high for this module and require flexibility from technical and support staff as these rooms are multipurpose and are used to serve other modules in 3rd and final year. In theory each lab was designed to accommodate 30 students however an average of 15 students per lab works well for both staff and students.

Other activities also have a requirement for space throughout the semester. These include space for poster and public presentations (we use the foyer of the engineering building for this) and space for the final soccer competition which takes place in the student recreation facility (the Hub).

CONCLUSIONS

The use of project based learning as an introduction to engineering for first year students at DCU has been a great success. This module has resulted in a very high level of technical output from 1st year undergraduate students and a high level of staff and student engagement. The module encourages self learning, group interaction and a high level of team work. It also forges relationships between 1st years which continue throughout the duration of their engineering degree. Students also see the relevance of engineering science and a range of other 1st year subjects in the design process and the module was found to enhance student confidence and skills.

REFERENCES

PERSONAL REFLECTIONS OF A 1ST YEAR POSTGRADUATE STUDENT

Lorna Fitzsimons and Brian Corcoran

School of Mechanical and Manufacturing Engineering, Dublin City University

E-mail: lorna.fitzsimons4@mail.dcu.ie

ABSTRACT

Undertaking a postgraduate research degree can be a very exciting and daunting experience. The aim of this paper is to relate some of the experiences and reflections of a first year postgraduate engineering student. There have been other articles written on the PhD experience, however I believe that this paper offers insights into the industry based project experience, the benefits and drawbacks of multiple supervisors, and it offers the perspective of a student on an early point of the postgraduate learning curve.

INTRODUCTION

The transition from secondary school to university is a major change; supports are in place, however, to make this transition as smooth as possible. Like school, the undergraduate syllabus is very structured, mainly exam based, and timetabled; generally, if the student puts in the work and makes use of any required support facilities, good results can be expected. The change from undergraduate to postgraduate study is very different, armed with a project proposal, a supervisor or two (sometimes more), and research funding the enthusiastic postgraduate embarks on three years (hopefully) of cutting edge, exciting research, well how difficult can it be?

To put this paper in context, I am a mature, first year postgraduate engineering student in Dublin City University (DCU), I am funded by IRCSET and my research is industry based. My research project involves plant energy characterisation and optimisation. Although the research funding may not fill the coffers, I personally believe that getting funded for interesting research is a privilege.

Embarking on the PhD/Research postgraduate experience can be intimidating; thankfully there are several sources of sound advice. The website Find a PhD.com contains many helpful articles which aim to assist the new postgraduate student [1]. These articles include advice on thesis writing, the expectations of a PhD supervisor in computer science, and in general, several PhD survival tips. One of these articles, “Learning to Survive the Ordeals of writing a PhD” discusses the challenges of a mature student and parent writing a thesis in the social sciences field. There are also books on the market, such as How to Get a PhD [2]. Another interesting study was a survey of 2,000 doctoral students that was carried out in the United States in 1989; this research formed the basis of several subsequent articles and offers interesting and valid insights into the world of the postgraduate research student [1].

The objective of this engineering education paper is to relate some of the personal experiences and reflections of a first year postgraduate student. It is very much a personal reflection on the first ten months of research, but hopefully, it may highlight some of the difficulties associated with the transition to fourth level study to supervisors, and give heart to other first year
postgraduates going through the transition. There are three main headings, first I discuss some of the differences between undergraduate and postgraduate study. Second, the paper discusses the ‘supervisory management’ element. Third, I reflect upon some of the specific benefits and challenges of an industry based research project. Essentially, the goal of this paper is discuss the main differences between postgraduate and undergraduate study, and also to discuss some key differences between academic and industry based projects.

UNDERGRADUATE vs POSTGRADUATE STUDY
What are the main differences between undergraduate and postgraduate study? Success in both requires self-motivation, discipline, a good work ethic and time management. There are key differences, however; in undergraduate study the course is mapped out, the examinable syllabus is provided in books/notes, past exam questions are available, and practice questions are carried out in tutorials. Generally, the expectations of the lecturers are relatively clear and are reflected in the end of semester exam (although this can vary from lecturer to lecturer). Research is very different, the postgraduate research project may not have a pre-determined structure, and this is both good and bad. This structural flexibility enables the student to work at suitable times maximising concentration and effectiveness; flexibility is a godsend for me as a parent trying to maintain a work/life balance. The lack of structure can have a downside, placing the onus firmly on the student to put in the hours and manage the project successfully. Although the project short and long-term goals are usually determined in conjunction with supervisors, the student is largely responsible for planning and organising their own workload.

There is also a difference in the social aspect of postgraduate study, it can take a while to settle into undergraduate study, but attending classes, labs and tutorials with fellow students makes getting to know people a bit easier. In the postgraduate’s case, there generally isn’t the same interaction with other postgraduate students. The postgraduate office is generally hushed with solitary students tapping away on PCs, and there isn’t the same banter that goes along with hanging round before lectures and labs. It takes longer to get to know people and there definitely isn’t the same downtime that goes along with undergraduate life. However, when postgraduates do get a chance to talk, the discussion (among other things) of people’s research projects and their associated snags and successes can be very heartening and keeps everyone else going. Organising social interaction time outside the working day can really help to motivate and encourage postgraduate students, leading to sharing of experiences and ideas.

Managing a research project can be really exciting, involving new learning and interesting ideas, however, it is not easy learning to collate the huge influx of information in year one. Although honours engineering degree typically courses have a high academic and theoretical content, the new postgraduate is often not prepared for the academic rigour that is expected in fourth level study. Project proposal in hand, the first step is to carry out a comprehensive literature survey. Depending on the level of previous research carried out in one’s area, it can sometimes be difficult to know where to begin looking for relevant information. Identifying key books, journals and trade magazines early on makes life much easier. In my experience, there were very few relevant academic articles at the start of my research; it was only when delving deeper into a more specific research area that the research field opened up. Initially, it can be difficult to ascertain what information is relevant and what is not, the hardest thing I found about embarking on the first year was the self doubt and all the ‘enough questions’:

- Is the quality of my work good enough?
• Am I intelligent enough to do research?
• Have I really understood and critically evaluated that paper thoroughly enough?
• Where does this paper fit into my research?
• Have I read enough papers, have I missed some key papers?
• There is too much information out there.
• There is too little information out there.

However, as the research field becomes more familiar, and both experience and confidence grow, the literature survey becomes more straightforward. Writing a first paper (in columns and very academic looking) is great, but also quite daunting, thankfully help was at hand. Aside from the help given by my academic supervisors, Dublin City University (DCU) offers a course in Research Methodologies to taught masters and research postgraduate students. This course was really useful; engineering undergraduate projects can tend to be quite practical, often the extensive and critical literary survey is not required. The DCU course thoroughly covered aspects of literature searching, managing references, critically evaluating publications, writing journal papers/theses, and statistical evaluation methods.

Progress evaluation is another key area that is very different between taught courses and research courses. Again, this leads to the constant questioning of whether one’s work is good enough. Supervisory guidance and feedback is essential to setting the quality standard for written work. In fairness to supervisors, certain quality levels are expected and supervisors shouldn’t have to correct shoddy work. However supervisors should be aware that the average postgraduate student may not have much experience submitting work for outside peer review, and as yet may not possess the academic argument and rhetorical skills of our elders.

The postgraduate tutoring or lab demonstration requirements, expected by universities, offer invaluable teaching and communication skills experience. The undergraduate student interaction is great and I found it really enjoyable; trying to explain concepts and methods clearly to others is a great indicator of how well one understands the particular subject material. For my particular scholarship funding, the maximum extra-research work allowed is six hours per week. In my case, teaching requirements including revising the material, preparing solutions and/or correcting work began to impinge on research project time. This was discussed with my academic supervisors and following their intervention, my workload balanced out in the second semester. It is also a good idea, in my opinion, to match tutors to their interests and aptitudes. A tutor that has no interest in, or understanding of, a particular subject is not in the best position to explain complex ideas to others.

The schedule of the postgraduate project differs from the semester/term based academic year. In undergraduate study, there is the battle to keep up with all the many continuous assessment assignments during term time. Then there is a study break for exam revision, followed by exams and another break – i.e. there always seems to be light at the end of the tunnel. Study pressure and the workload can be frantic, but they are finite. Postgraduate study can sometimes feel never-ending and overbearing, particularly if things hit a dodgy patch. Unlike a lot of nine to five full-time jobs, it is not all that easy to switch off from research. Combined with the self doubt and the worry of not actually coming up with something novel, in first year the long term research outlook can be stressful.
SUPERVISORS ROLE

According to the DCU postgraduate research regulations, the responsibilities of the supervisor(s) shall be [3]:

- to advise the student on the selection of the research topic and the nature and quality of the programme of research to be undertaken;
- to ensure that the student acquires training in the methodology of research and scholarship and in the skills necessary for sustained independent effort;
- to provide contact and guidance through regular and systematic meetings; to request regular written submissions as appropriate and to provide constructive evaluation and criticism in reasonable time;
- to ensure that the student is made aware of any inadequacies of progress or standards below that expected for the degree registered and where necessary, to advise on withdrawal from the programme;
- to liaise with the external supervisor of the co-operating establishment;
- to advise on the methodology and form of presentation of the thesis and its subsequent examination;
- to advise the Registry, through the submission of annual written reports, of the candidate’s progress. These reports should include details of the frequency of contact maintained with the candidate and an appraisal of the progress of the work to date.

These are the regulations, but how does the supervisor – student relationship work in real life? Are these regulations adequate for the needs of the novice postgraduate student? Here are some of my musings on the nature of supervision. The postgraduate student is responsible for the success of his/her research project, having said this; the supervisors’ role also has a huge effect on the project outcome. An interested supervisor can make a research project immensely more rewarding and enjoyable. From the students’ perspective, there is a big difference between the supervisor that keeps abreast of students’ research work and shows an interest in it, and the supervisor that is merely making up the research numbers. The same applies to the supervisors’ perspective, supervisors expect their students to show initiative, be interested in their project, and to be responsible for the quality of produced work. Expectations need to be articulated and managed on both sides, in the 1989 United States postgraduate survey mentioned earlier, 51% of students felt that faculty members were not explicit in their expectations of students [4]. Often students do not realise the other research, teaching and administrative responsibilities of the academic staff. Accurate, proof read work, handed in on time, can make the supervisors life much easier. This should work both ways, students’ work that is handed up on time and proof-read, should be returned to the student in a prompt fashion if possible. From the students’ point of view, it is not ideal to be frantically amending work two hours before a submission deadline. In essence, initiating and maintaining a good student-supervisor relationship is a key project goal; mutual respect and trust positively influence any research project.

I have several bosses, both academic and industrial. Dealing with multiple supervisors, on the one hand, offers many advantages, joint supervision can be synergetic and bring several viewpoints to the discussion table. Multiple supervisors with varied expertise contribute different approaches, methodologies, and visions for the project; the downside is that it is almost impossible to keep everyone happy. In the 1989 survey, 63% of students either sometimes or always felt that they could not satisfy the “conflicting demands of various people” [4]. A mix of academic and industrial supervisors ensures that the research remains grounded and focused, the industry based supervisors tend to have a specific question they want answered, primarily how to reduce cost. The academic supervisors have the academic method of best addressing and answering that question. Engineering, by its nature, attracts reasonably grounded academics, and industry mentors tend to have an engineering background, so the two often have the same
outlook and approach. Although, having several brains to pick can be inspirational, it can also be confusing. Interpreting one person’s vision of how things should be done can be difficult, adding another to the mix can truly confound!

ACADEMIC vs INDUSTRY BASED PROJECTS

There are various types of engineering projects, from the purely mathematical and theory-based projects to those that involve significant industrial input and collaboration. There are several interesting benefits and challenges of industry based projects compared to academic projects. Academic projects often follow on from, and build on, previous research. This offers the new postgraduate student a good starting point, and is the basis of a thorough literature review. The academic research field is often well established, with previously identified key journals, research bodies and authors. The first six to eight months or so can involve retesting others work and reviewing related journal articles. This greatly reduces project start up time. In contrast, the industry based project may not have a literature history, research may be project based and related in trade journals. Some industries are very secretive about research, and do not publish findings in the academic press, therefore it can be difficult to access information, often one doesn’t have the firm academic footing that inspires confidence. Also, the practicality of familiarisation with two research locations, and two sets of people, adds to the workload. From my perspective, in the first year, there were two steep learning curves to climb; one which was discussed earlier was familiarisation with the research field, and the other was familiarisation with the industry partner.

Beginning an industry based research project is like starting two new jobs at once, there is an initiation period for both the academic and industry streams. Practically, there is the administrative side of getting IDs, initiation health and safety training, orientation, meeting key personnel, getting set-up with offices, laptops, familiarisation with systems etc. For large organisations, it can take time to settle in and find one’s way around. Then there are the preliminary project meetings, meeting industry mentors, and trying to define early project goals and targets. Initially, my research colleague and I were included in internal energy project meetings and soon got up to speed on current industry partner projects. In retrospect, this orientation went very smoothly due to good supervisory planning.

Industry based projects have an advantage in that they are reality based, from a mechanical engineering basis there are real plants, real data, and real engineering problems. There is also a wealth of engineering and process know-how. Industry collaboration, from the students’ perspective, places the engineering function into a greater overall business context. The interaction between the various business and engineering functions becomes clearer too. Attending and contributing to project teams has also been a great experience: seeing the development, implementation, management and success of some projects, as well as the ‘falling off the radar’ of others has been very educational. Observing the synergy, but also the challenges of multifunctional teams, and their respective agendas, has been enlightening. One learns a lot very quickly, working in the dynamically changing business world. From the ‘real world’ educational perspective, industry based research is a rapid, intense teacher. From the long term research project perspective there are some challenges. Long term academic research, e.g. the three year PhD, does not always fit in with industry cost saving projects that need to be implemented before the next quarter’s financial performance indicators. The dynamic nature of business means that things change very quickly, what is popular and a great idea one month can
fall out of favour quickly the next. The expected payback on engineering cost reduction projects can be as low as six months. This can lead to a rapid, refocusing of effort from one project to the next; my research project theme changed quite a bit from month to month. People in industry change quickly too; my initial industry mentor left three months after the start of my research project. All in all, defining my project area has been the most difficult challenge in the first year of research. I thought that my initial project proposal had my project direction mapped out exactly, however, be warned - there is often a difference between the vision of the project proposal and reality. There are two other challenges of industry based research. First, the postgraduate can often feel very much the outsider (the annoying one), constantly relying on industry personnel to provide access to information, and equipment. Most people try to help out, but sometimes the student can feel completely disenfranchised, one can end up emailing people two or three times without response, trying to get information. The academic based project allows much more autonomy in comparison; the student generally has a rig, access to test equipment, and within reason can test away to their hearts content. Second, confidentiality and IP protection plays a major role in certain industry partner’s corporate culture. In my project, process and data protection is paramount; all written work must be assessed and passed for outside publication. Preparation for conference paper deadlines begins early to ensure proposed papers follow the necessary review channels. So, although there may be an abundance of data and information, publication of the information is not permitted. IP is highly valuable in today’s business environment, so it is understandable that protections are in place. From the ‘publication-hungry’ postgraduates’ point of view, this can feel very restrictive at times, like a form of censorship.

CONCLUSIONS
This personal reflection has addressed some of the important issues I encountered in the first ten months as a postgraduate research student; these have included the transition to postgraduate study, the supervisory relationship and the differences between industry-based and academic projects. The main points can be summarised as follows:

- Postgraduate social networking should be encouraged and organised.
- Progress evaluation and the expectations of supervisors need to be more explicit, particularly in the first year.
- Building a good supervisor relationship is paramount to project success.
- There are both advantages (multiple inputs - ideas, viewpoints, technical knowledge) and disadvantages (conflicting demands, can’t please everyone) to having several supervisors.
- There are both benefits (‘real world’ education, real engineering systems, and process expertise) and drawbacks to industry based projects (PhD and industry project timelines very different, dynamically changing objectives).

REFERENCES
[1] Find a PhD.com, [on-line], accessed 30/7/08.
USING PEER REVIEW TO ENHANCE THE QUALITY OF ENGINEERING LABORATORY REPORTS

Greg Foley

School of Biotechnology, Dublin City University
E-mail: greg.foley@dcu.ie

ABSTRACT
Peer review of third year bioprocess engineering laboratory reports was introduced in an attempt to improve the standard of report writing in the BSc in Biotechnology degree programme at DCU. Preliminary results suggest that the review process leads to improved report writing skills. The student response to the initiative was very positive but it was strongly felt that the process should be anonymous. On average, marks awarded by students were higher than those awarded by the lecturer but there was a slight tendency to award more extreme marks.

INTRODUCTION
A recent survey of technical professionals found that they spend more than 40% of their time writing. The ability to write in a clear, concise and consistent way is, therefore, an essential part of science and engineering training. Undergraduate students must frequently write reports describing their laboratory experiments and despite their being provided with detailed handouts on report writing, it is still found that basic errors frequently recur. These range from simple typing errors, to unlabeled or incorrectly labeled graphs, to structural errors. Since the students do know what is required of them in report writing, these errors would seem to be due to a lack of attention to detail on their part.

The value of peer review in developing both critical thinking and student writing skills is well documented. The first drafts tend to be improved because the students know that their peers will be reading their paper. They also tend to think of their paper as being written for a general audience rather than being written specifically for the instructor. Additionally, the student is provided with a formal opportunity to reflect on his/her work and to revise the draft in response to the review. The reviewer benefits by being forced to consider the elements that lead to an effective report and to learn from their fellow students. However, the lecturer must provide sufficient structure and guidance to ensure that the students provide realistic and instructive reviews that are not overly positive or negative.

The main objectives of the pilot project described here were to address three areas of student writing: (i) a lack of attention to detail in submitted laboratory reports (e.g., careless proofreading, units missing on graphs etc.), (ii) a general tendency to be careless and imprecise in the use of language (Table 1) and (iii) a lack of a clear understanding of some
basic ideas regarding appropriate content and style in scientific papers (e.g., results in the Materials and Methods section etc.).

To address these issues, it was proposed that write-up sessions would be scheduled where students would be given some formal instruction in technical writing. Furthermore, peer review was introduced whereby each student would review the laboratory report of one of his or her classmates. The peer review would serve to make students more careful about their submitted work and, by reviewing other student’s work, become more aware of those areas of report writing in which they themselves might be prone to making errors.

Table 1 Some quotes from student reports illustrating poor and imprecise use of language

- “Xanthan gum, a non Newtonian liquid was used as it adds terminal viscosity which lowers the jacket convection”
- “Heat transfer is plotted against time and the slope gives us the rate of heat transfer.”
- “This experiment hopes to investigate how different agitation speeds and different flowrates of the cooling liquid affect the heat transfer coefficient, U (W/m²K)”
- “The graphs obtained were so “perfect” (their R values were exactly 1) that the slopes were unusable values.”
- “Turning the steam nosel to sterilise the vessel, turn the valve in a clockwise position until the sample starts coming out.”
- “Data was representative of mathematical approximation, and both factors investigated that effect U (W/m²K) were found to be true.”

METHODS
The class was divided into 4 groups (A-B) consisting of 3 or 4 students. It should be pointed out that this was an exceptionally small class in comparison with the usual third year class cohort, which is normally in the range 25 to 35 students. Each group did 4 experiments, each lasting a full day and everyone was required to write a full report on two of those experiments. Reports were to be written as a 6-page research paper and students were provided with a ‘Guide for Authors’ to mimic a real research paper submission. The laboratory schedule is outlined in Table 2.

Each student reviewed two reports with the aid of the reviewer form shown in Table 3. They reviewed the report from a student who was not in his or her group and whose report covered an experiment that the reviewer had not yet done. The first review was carried out completely anonymously, i.e., the report was assigned a manuscript number by the lecturer rather than containing the name of the author. A similar approach was used for the second report but in this case the review session was unsupervised and, as revealed by the student survey, anonymity was not maintained.
Table 2 Laboratory Timetable

<table>
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<tr>
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<th>Monday</th>
<th>Wednesday</th>
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<tr>
<td></td>
<td>Exp 1</td>
<td>Exp 2</td>
</tr>
<tr>
<td>Wk 1</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Wk 2</td>
<td></td>
<td>Write-up session</td>
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<tr>
<td>Wk 3</td>
<td>C</td>
<td>D</td>
</tr>
<tr>
<td>Wk 4</td>
<td></td>
<td>Write-up session</td>
</tr>
<tr>
<td>Wk 5</td>
<td></td>
<td>Re-write session</td>
</tr>
</tbody>
</table>

For assessment purposes, *the student reviews did not count towards the report writer’s mark* but the review itself was assessed and marked by the lecturer. On receipt of the student review of their second report, students were given the opportunity to make any necessary modifications to their report in a re-write session before final submission. All work was conducted electronically.

Table 3 Peer Review Form

<table>
<thead>
<tr>
<th>Reviewer Name</th>
</tr>
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<tbody>
<tr>
<td>Manuscript Number</td>
</tr>
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Use as much space as you need to write brief answers or comments as appropriate. Email the completed form to folgreg@gmail.com. *The completed form should not exceed three pages in total.*

1. Give a brief overview of the main merits and demerits of this report.

2. Does the Abstract describe what was done in the experiment, how it was done and what was found? Is it of an appropriate length? Is it self contained?

3. Does the Introduction set the scene and describe the aims and objectives of the experiments?

4. Is the Materials and Methods section clear and would you be able to repeat the experiment based on the information provided?

5. Are the Results described clearly and in a logical order? Are the Tables and Figures legible and appropriately labeled? Is there any duplication of material or provision of unnecessary material? Is there appropriate discussion of the results, including discussion of the quality of the data?

6. Do the conclusions follow logically from the results?
Based on a marking scheme of: Abstract (20%), Introduction (15%), Materials and Methods (20%), Results (30%), Conclusions (5%), Overall Presentation (10%), give this paper a mark out of 100.

**Overall Mark:**

**Results**

Figure 1 shows how the student marks compared with the lecturer mark for both reports. The root mean square difference on the first report was 17% while that on the second report was 11%, suggesting that the student marks were in general quite realistic and became more consistent with the lecturer having gained some experience. For both reports, students were more likely to be more generous with their marking than the lecturer. Analysis of the report marks showed that the average lecturer mark on the first report was 54% while the average on the second was 59%, suggesting some improvement in the quality of the student reports. However, this may have been due to feedback from the lecturer and may not be solely due to the incorporation of peer review into the laboratory. Likewise the average mark awarded by the students increased from 61% in the first report to 64% in the second.

![Figure 1](image-url)  
*Figure 1* Comparison of student marks with lecturer marks

Student opinion was surveyed and there was unanimous agreement that the introduction of peer review was a positive development. Some student comments are listed in Table 4. Given the importance of anonymity, peer review must be carried out under the supervision of the lecturer or demonstrator under exam-like conditions.
The administration of the peer review system is potentially time consuming especially with large class groups. The lecturer must spend a considerable amount of time ‘anonymising’ reports, assigning reports to reviewers based on well defined criteria and coordinating the receipt and return of both reports and reviews. In this module, this was done electronically and required considerable care to avoid errors. Furthermore, the success of the peer review system depends crucially on the lecturer giving rapid feedback on both the reports and the reviews.

**Table 4** Some Student Comments on peer review

- “With the peer review system, after correcting a paper, flaws in your own paper were more obvious. Feedback was only constructive from reviewers so everybody was a winner.”

- “A possible but not essential improvement would be to emphasise the anonymous aspect of the course so some people could be swayed in decision making.”

- “I found the peer review, when done under anonymous conditions to be very constructive and raised the general standard of reports in the class. This is due to both having your friends view and scrutinising your paper, as well as detailed feedback about the paper. It was also useful to be put in the frame of mind of a teacher, forming the mentality of what to look for.”

- “I learned as much from the report writing and correcting as I would preparing for an exam. I nearly felt I learned more with less pressure and more enjoyable.”

- “When reviewing I found that I discovered mistakes in other reports that I had not discovered in my own. This made me much more careful when carrying out my second report.”

**Conclusions**

The incorporation of peer review into engineering report writing is undoubtedly a beneficial exercise. Furthermore, it can be achieved without excessive workload with small class groups (< 20 students). Further work is required however to see if this approach is logistically feasible with larger class groups.

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**References**


DEVELOPMENT OF A HEAT TRANSFER AND ARTIFICIAL
NEURAL NETWORKS TEACHING LABORATORY PRACTICAL
FOR BIOTECHNOLOGY STUDENTS

Brian Freeland, Sumsun Naher, Greg Foley and Dermot Brabazon

School of Mechanical and manufacturing Engineering &
School of Biotechnology, Dublin City University, Ireland.
Email: brian.freeland@dcu.ie

ABSTRACT
The paper describes a newly developed laboratory practical that teaches students how to
develop an Artificial Neural Network model and its possible use in bio-processing. An
emphasis is placed on giving students “hands on” experience with bio-processing
equipment, namely bio-reactors and data acquisition systems in an attempt to help
prepare them for work in bio-processing and chemical engineering industries.

INTRODUCTION
The BSc in Biotechnology offered by DCU is a multidisciplinary degree program
encompassing Biological sciences and Bioprocess engineering. The main emphasis of the
course is directed towards Biological Sciences as 60% of the course material is made up
of; Microbiology, Biochemistry, Cell Biology, Immunology and Molecular Biology. The
remainder of the course material deals with Bioprocess Engineering, Mathematics and
Chemistry. The main bio-processing modules deal with heat and mass transfer, fluid flow
and bio-reactor theory. In the past few years it has been observed that students seemed to
be more engaged with the new aspects of the biology side of the course. Within the last
few years there has been efforts to modernize the engineering laboratory program to
engage students and renew enthusiasm for engineering and its applications in
biotechnology. To this end in 2006 a “design and build” project was introduced where 2nd
year students followed a complete design process; designing and building simple heat
exchangers using heat transfer theory [1]. This project was very well received by
students, and the “hands on” approach with problem solving requirements at different
stages during the lab was well received. In 2007 a bio-ethanol production laboratory
practical was introduced for third year students, which was again a “hands on” practical
that demonstrated the direction of some bio processing research.

Interest in teaching techniques for engineering has increased over the years. A lot of work
as been conducted into how best to present classical theories to students and the skills
required by graduates. There is an aim to try and match their learning styles with teaching
styles and methods. Emphasis has been placed on how universities equip students for
industry. More and more practical based teaching is employed either using virtual
laboratories [2] or using full laboratory practical’s [3]. In Biotechnology and the
processing industries the requirement for graduates to be able to problem solve and work
with processing equipment is critical. Therefore hands on experience on processing
equipment during their undergraduate studies is a requirement. It was decide to develop
a new laboratory to teach heat transfer and the use of bio processing equipment while demonstrating new lines of research in bio processing engineering. The aim of the developed lab would be to help engage students and introduce them to the kind of research being conducted in the school.

**Heat transfer in stirred tank reactors**
Stirred tank reactors are the most important equipment used in biotechnology processing and chemical engineering. They are used for many functions in bio processing such as growing cells, cultures, food production, brewing and for chemical production. They vary in size from 1 litre lab bench scale to 10–30 litre pilot scale to 1000 litres and above for production scale. They can be used in a variety of field’s examples of such are; testing new drugs, producing bakers yeast, Bio-ethanol etc. Temperature control is critical for bioreactors as cell growth generate heat that need to be removed, while maintaining the broth within small operating temperatures (30°C–40°C). Due to the significance of temperature control it was decided to examine the overall heat transfer coefficient (U) in a stirred tank jacketed vessel.

**Artificial neural networks**
Artificial neural networks (ANNs) have been used for diverse applications such as pattern recognition, environmental modelling, machine calibration, chemical engineering and economic modelling. They have been used for several functions such as optimisation, simulation and prediction purposes. The main reason for ANN’s use in so many diverse fields is that they have been seen to perform very well in comparison with existing statistical techniques. This is due to their following features:

- Nonlinear/curve fitting abilities.
- Insensitivity to noise within the data [4].
- Ability to generate acceptable models from limited data [5].

ANNs are starting to be used extensively in heat transfer problems as their abilities stated above make them idea for modeling heat transfer, which in its essence is a non linear problem. The use of Artificial Neural networks for the lab will demonstrate new up to the minute research in bio-processing engineering, as the use of ANNs for heat transfer problems is a very new field, with several papers published in even the last three years [6, 7].

**Student Learning Styles**
In order to assess the learning styles of a significant sample of the Biotechnology student population, the 2nd year students were given Fielders learning styles questionnaire. The outcome of which would be used to conclude what type of teaching best suits biotechnology students. The survey was conducted on 19 students, 86% of the total class. The survey results showed that 80% of student’s surveyed are strongly visual learners, they learn better by reading charts and diagrams to explain concepts rather than presented in a verbal manner. Most of students are balanced between sequential and global, meaning that they like to be presented the full picture of concepts at the start of a lesson and then, introduced to the concept piece by piece. 75% of the class are active learners, with the rest balanced and a small percentage reflective. Its surprising that some students are reflective as studies have show that the engineering and science students are heavily
active based learners rather than reflective. From the results of the fielder surveys it can be determined that laboratory practical’s and teaching using problems based learning, are techniques that would best suit, biotechnology students. These results also ties in well with general engineering student, who are generally more active and visual learners [8]. Any laboratory practical should be set up in a sequential manner, using a lot of visual aids to explain concepts etc. Students should have a lot of input into the practical, and have a sense of ownership over the practical and their work, this was seen to be a beneficial motivating factor with the design and build heat exchanger project in previous years [1].

Students should be introduced to the following concepts during the laboratory:
- Artificial neural network modelling.
- Experimental setup.
- Heat transfer in bioreactors.
- Industrial specification process equipment; valves, pumps flow meters, data acquisition and computer control.
- Piping and instrumentation (P&ID) diagrams.

RESOURCES AND METHODS

**Overall heat transfer coefficient (U)**

An equation was developed from first principles using heat balance equations to calculate the cooling overall heat transfer coefficient in a stirred tank jacketed vessel. This is used in existing heat transfer lectures and tutorials given in 2nd and 3rd year. Hence the students are expected to know it before they start the lab. They will have to calculate U for their five experimental runs, and the labview program will check their answers, if it’s within 10% of actual U, it’s saved into the dataset along with the input variables for the given run.

\[
\ln \left( \frac{T_0 - T_{wi}}{T - T_{wi}} \right) = \frac{M_w C_p}{M C_p} \left( 1 - \frac{1}{\beta} \right) t \\
\beta = \frac{1}{1 - m \frac{M}{M_w}} \\
U = \ln \beta \frac{M_w C_p}{A} \left( \frac{W}{m^2 K} \right)
\]

Where: \( M_w \) is the Mass flow-rate (m3/s), \( M \) is the mass of process Fluid (Kg), \( N \) is the agitation Speed (rpm), \( T \) is the current vessel bulk temperature (°C), \( T_0 \) is the original Tank Temperature (°C), \( T_{wi} \) is the input coolant temperature (°C), \( A \) is the Heat Transfer Area (m2) and \( C_p \) is the specific Heat Capacity of Water (J/kg°C). If the correlation is correct a plot of LnT mean Vs time should give a straight line whose slope can be used to calculate Beta Eq.(2) and hence the overall heat transfer coefficient Eq.(3).

**Monitored variables and ANN input selection**

To calculate U using equation 3 the following process variables must be monitored on the reactor: \( T, M_w, T_{wi} \). In order to develop an artificial neural network model physical inputs were to be selected that were known to effect heat transfer in stirred tanks [9], [10]. These variables had to be monitored and recorded, along with the corresponding U for each experiment in order to build a data set to train the neural network. The selected inputs can be seen in Figure 1.
Why not use existing Bioreactors?
The pilot plant already has 3 fully operational 10l Sartorius Bioreactors. These were not used for the new teaching lab as it would have proven more costly to alter them, adding more process monitoring rather than construct a new one, as sterility of the process fluid will not be an issue, i.e. the product isn’t important. Also the three bioreactors are used extensively in research and for 4th year projects, they are critical equipment, therefore the students couldn’t get full access to them if used for labs. As one of the main requirements of the practical is to give students experience of using industrial equipment it was decided that a custom made reactor, that has the same operational specifications as a pilot scale reactor should be constructed and used for the lab.

![Artificial Neural Network with model inputs and output](image)

Artificial Neural Networks requirements
A base data set was gathered to allow for training of the neural network. A full factorial and central composite design was used to gather a data set with 68 data points. This described the entire operating conditions of the system. The initial base model produced a mean relative error of 5.6% and Max relative error of 10.8%. It’s thought that towards the end of the semester the student’s model should attain better accuracies than this due to more training data available.

RESULTS
A stirred tank reactor was designed and constructed for the project, using an existing jacketed vessel. The main data acquisition and rig control components are illustrated in Figure 3b. The rig has safety features such as; over temperature shut off and fail safe cut off on all components.
Figure 2: (a) Picture of heat transfer rig and (b) schematic of rig control.

Figure 5: Home welcome screen for laboratory.
Lab Structure (1 day)
The lab is started from the welcome screen in the LabView interface, all options can be accessed from there, except the ANN model development, the uses Trajan neural network simulator software.

1. **Review heat transfer theory for bioreactors:** Students are given the opportunity to review bioreactor heat transfer theory, this would be a follow on from their lecture notes, however its not parts of the lab as such, just an available resource in the labview program.

2. **Piping and Instrumentation Diagrams (P&ID):** Students are guided through the symbols for the process equipment on the rig. As part of the report they will have to draw a P&ID diagram for the coolant system.

3. **ANN theory:** A simplified overview of artificial neural network theory was supplied, this is not meant to go into much detail, and it should help the global learners understand the training process later on during the lab.

4. **Show current data set:** The students are shown the current data set and asked to decide what five experiments to run that will be added to the data set and aid the development of the neural network, to give a better representation of the operating conditions. Over the weeks as the data set is increased the accuracy of the neural network should increase provided that the experiments are performed correctly. This should demonstrate the online uses on ANN in industry. It would be possible to just give students a full data set and perform an ANN tutorial using that data to develop the models however it was the author’s intention to develop a lab that show students a real world Biotechnology application to neural networks and of course to get “hands on” use of bio processing equipment.

5. **Show and explain rig and its operation:** The labview interface guides through the experimental rig operation and rig settings that can be adjusted when setting up their experiment.

6. **Perform experiments:** The coolant flow rates, fluid concentration, impellor type and impellor speed is setup, using the labview program, to monitor variables before the data acquisition is started and experiments run. All process variables are displayed on the labview interface during data collection as seen in Figure 5.

7. **Calculate the overall heat transfer coefficient:** The student calculates U manually from the information given in a data analysis screen. They input their answer, if it’s within 10% of the actual (LabView calculated) U its accepted and saved into the data set used for ANN development.

8. **Develop the Artificial neural network model from the data set:** An additional the lab manual is supplied to demonstrate a step by step approach to develop an ANN model for the data set.

9. **Model performance evaluation:** The performance of each lab groups developed model is determined during the lab, using mean relative error and max relative error deviation of model output from experimental U. Also towards the end of the semester the last models performance is review by the whole class, to determine what effect the addition of training data had on the modelling performance.
DISCUSSION AND CONCLUSIONS
A heat transfer rig was designed and constructed using a limited budget. The bioreactors dimensions, operating conditions[11] and components were typical of a pilot scale bioreactor. A budget National instrument card was used very successfully for data acquisition and control of the rig, and a PicoTech TC08 thermocouple data logger integrated successfully into the labview environment. Labview was used successfully to develop a simple user interface that the students should be able to navigate with ease. The interface was set out in a sequential manner, relying on diagrams of the process to illustrate the changing process variables on the rig, an indeed the operation of solenoid valves etc. The students should get a feel for industrial bio processing equipment and the integration of such equipment with data acquisition and control software. Also students should have experienced “up and coming” research within bio processing and see the applications of a research topic, i.e. Artificial neural networks in an industrial setting.

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THE DESIGN OF A PORTABLE PROGRAMMABLE LOGIC CONTROLLER (PLC) TRAINING SYSTEM FOR USE OUTSIDE OF THE AUTOMATION LABORATORY

Michael Barrett

FAS Training Centre, Athlone, Co.Westmeath, Ireland.
Email: michael.barrett@wr.fas.ie

ABSTRACT
Programmable Controllers are predominately laboratory based subjects as they require “hands on” electrical wiring, interface to industrial electrical components, to Human Machine Interfaces (HMI) and may be networked. As PLC courses evolve to incorporate the IEC 6-1131 defined programming languages with the resultant extra software theory learning requirement and an increasing demand for in-company courses a requirement arises for a PLC system which is portable and can be accommodated in a training or class room. This paper seeks to address this issue.

INTRODUCTION
The PLC is a robust industrial computer which accepts input data, both digital and analogue, from switches and sensors and controls outputs to drive devices such as motors, pneumatic devices and status indicators. At its most basic the PLC replaces relay logic circuits, at its most advanced it can implement Proportional Integral and Derivative (PID) control algorithms over networks. While the Programmable Controller is by far the most common process control mechanism in the manufacturing spectrum of large to small business it has also found a niche in environment control, food processing, mining and in automated test equipment [1] [2]. Programmable controllers were developed in the U.S. for the motor manufacturing industry in the 1960s. By the late 1970s they appeared in the Irish industrial scene. Today due to their increasing sophistication and falling costs they are to be found in the smallest production environment. The PLC programming environment may be dedicated terminal or a Personal Computer (PC). Latterly, with the event of the range of programming languages defined by IEC 6-1131 the PC is the favoured programming environment. Ladder Logic (LL) is currently the most popular language [3]. There is however, anecdotal evidence that the other defined languages are slowly gaining acceptance.

TRAINING AND EDUCATION
As the PLC is part of an automated system there are several modules that should be included, or be a prerequisite, in any course. Those modules are software engineering, electrical design and in some cases, mechanical design. Software engineering includes applying a Software Development Life Cycle (SLDC) approach to the system being designed and the ability to write the control program. Electrical design encompasses electrical panel design (and construction) to the relevant standard. The PLC apart from being run as a “stand alone” course is now an integral
part of courses ranging from agricultural engineering to mechatronics and industrial automation. PLC courses, as for all control engineering courses, must deliver “a balance of practical skills and theoretical knowledge” and as such are laboratory based [4]. Increasingly, in response to demands from industry PLC courses are being run in-house, in training rooms, away from the traditional venue of the automation laboratory using hardwired “kits” and PC based simulators.

THE PLC TRAINING SYSTEM DESIGN BRIEF
The aims of the new proposed training system are that it must support the sub-disciplines of software engineering, computer programming and panel wiring. While the basic system must support digital I/O it should be expandable to support analogue handling and non proprietary networking. The system should have components from multiple users – it should not be seen as favouring a particular manufacturer. The detailed objectives being that it must:

1. Be safe;
2. Be portable;
3. Fit comfortably on a desk;
4. Incorporate an industrial standard PLC;
5. Interfaces to a PC;
6. Support Ladder Logic and at least two of the other IEC 6-1131 defined Languages;
7. Interface with common industrial electrical components;
8. Be low cost as continuing transportation will likely result in the need for frequent component replacement;
9. Be expandable to facilitate analogue handling;
10. Be expandable to facilitate Ethernet networking.

A REVIEW OF AVAILABLE PORTABLE TRAINING SYSTEMS
There are two sources for training systems, commercially available ones and those proposed by education. A review of both is useful.

1 Commercially Available System
Commercially available portable training systems fall generally into two categories:

- Hard wired “kits”;
- Simulators.

- Hard wired “kits”;
A kit generally consists of a PLC incorporating banks of switches to simulate input devices and lamps to simulate output devices [5]. They do not facilitate interfacing industrial electrical components to the PLC. They are useful for teaching programming only, for experienced programmers to explore new programming techniques and for black box software testing. They do not however, for entry level programming students, provide the experience of selecting and connecting actual components to the PLC and generating the Input / Output (I/O) List to document those connections. The I/O List is a vital part of the documentation required for effective program design and maintenance [6].

- Simulators
Simulators may be sub-divided further in to two categories:
PC based using an actual PLC. Simulators generally have a range of industrial processes (“virtual machines”) such as “pick and place” and “tank level control systems” [7]. The programmer selects a “virtual machine” from a menu, writes the program to control it and downloads it to the PLC. The PC based simulator communicates serially with the PLC simulating the “virtual machine”.

In the second type the PLC and the machine or process are both “virtual”, that is no physical PLC exists. Again, as with the previous system the programmer selects a “virtual machine” from a menu, writes the control program on the PC based “virtual PLC”. The “virtual machine” is then controlled by the “virtual” PLC [8].

Simulators can be used effectively for engineering training generally [9]. However, for PLC training, as with the hard wired kits the simulators are best exploited by students who have the applied skills required to interface the PLC to peripheral devices, have some programming skills and want to develop those programming skills. The simulators in common with the hardwired kits do not provide the practical experience of wiring up the PLC, interfacing it to peripheral devices and generating the electrical drawings and the I/O List to document the system.

2 Training Systems Proposed by Education
A literature review of existing systems identified two that approached the criteria required for this project. Dickinson and Johnson describe a low cost PLC Trainer for use in a university level agriculture electricity course. The trainer is programmed with a PC, supports Ladder Logic programming and costs less than $500.

The trainer however, is mains powered and interfaces to a software simulator [10]. A PLC workbench was developed for use in the faculty of engineering at the University of Blue Nile based on a Siemens STEP7 PLC [11]. In this case, however the physical size was at issue, the workbenches being desk size required a dedicated room. None of those systems meet the current requirements.

DISCUSSION AND CONCLUSIONS
The new system consists of a simple timber structure in the form of an “A” frame rotated through 45°, see Figure1 (a), onto which is fitted an length of “DIN” rail onto which the components such as the PLC, Miniature Circuit Breaker (MCB) and electrical contactors are mounted, see Figure 1 (b). The PLC selected in the Mitsubishi Fx1n, 10 I/O capabilities, 24 Volt Direct Current (DC) operations. This PLC is selected because:

- It is powered by a low voltage supply for safety reasons;
- It support Ladder Logic (LL), Instruction List (IL) and Sequential Function Chart (SFC) languages;
- It supports, with the addition of an add –on module, Analogue Handling;
- It supports, with the addition of an add –on module, Ethernet networking.
- The electrical contactors are 24 Volt Alternating Current (AC) operations. A central power supply provides two supplies to each training system i.e. 24 Volts DC to power PLCs and sensors and 24Volts AC to supply the electrical contactors. The students have no access to the mains supply thus ensuring electrical safety. The system fits comfortably on a standard desk, see Figure 3
CONCLUSION

The system has been used in a classroom situation three times over the last year. The students were a combination of technicians, engineers and electricians all with industrial manufacturing experience. All had encountered PLCs in their work and were aware of their uses but only one had experience of programming or faultfinding. The training courses were problem based where students were asked to design a PLC controlled system to control two electrical contactors as drivers for three phase motors to run two conveyors. This involved analysing a requirements statement, producing an electrical drawing, producing SDLC documentation and connecting the PLC to the power supplies and peripheral equipment. For testing purposes test cases to test the requirements were generated. Black box and white box testing was carried out.

Feedback from participating students was positive, the “hands on” aspect being especially well received. While the system cannot substitute for the laboratory for advanced courses it has found a niche for the purpose for which it was intended, delivering introductory courses in situations where access to the automation laboratory is not feasible.

FUTURE DEVELOPMENTS

While the courses currently being run are confined to Ladder Logic programming and digital I/O it is proposed to extend the syllabus to include analogue I/O and the Sequential Function Chart (SFC) programming language. An increasing demand is emerging for training in data capture and Overall Equipment Effectiveness (OEE) measurement. By the addition of an Ethernet module OEE data collected by the PLC may be networked and presented on remote PCs as part of a Management Information System (MIS).
REFERENCES
AN ANALYSIS OF FINAL YEAR STUDENT PROJECT PERFORMANCE IN MECHANICAL ENGINEERING

Shadi Karazi¹, Dermot Brabazon¹, Philip Smyth¹, David Molloy²

¹School of Mechanical and Manufacturing Engineering, Dublin City University, Ireland
²School of Electronic Engineering, Dublin City University, Ireland
E-mail: shadi.karazi@dcu.ie

ABSTRACT
This paper describes a statistical analysis of the students’ results in mechanical engineering Final Year Project (FYP) at undergraduate level eight. Project marks of the final year students obtained over the past six years (2002-2008) were recorded and analysed. A detailed and comprehensive assessment of the marks achieved was examined. This included assessment of the presentation, report and progress results. This study provided an interesting insight into the trends of assessors’ marking and students’ performance. A gradual statistically significant reduction in student marks over these six years was noted. Reduced student performance over the last 10 years in Leaving Certificate mathematics along with the general fall of in the numbers of engineering students are discussed as possible contributing factors. Care must also be taken to ensure that marking is consistent and standard such that it fully and fairly expresses student performance.

INTRODUCTION
The School of Mechanical and Manufacturing Engineering at Dublin City University currently runs four undergraduate degrees programmes [1]. The (FYP) is a major component of most undergraduate engineering programmes of study. This project is designed to provide experience in practical project work and assess student’s competency in this area. A statistical analysis of the FYP marks in the Department of Electronic Engineering at the City University of Hong Kong was conducted in 2001. The purpose of this statistical analysis was to find the existence of discrepancy between the supervisor and second assessor in project assessment. It is found that the reason for the discrepancy is due to the excessively low marks given by one of the assessors. The outcome of this systematic approach using statistical analysis helped to identify those projects that needed to be reassessed [2]. FYP assessment has always been an important issue in the engineering undergraduate program. Teo and Ho developed a computerized system to manage project allocation and mark calculation [3]. It also contained a supporting system that can identify any discrepancy between supervisor and assessor. This systematic approach using statistical analysis used by Teo and Ho can highlight the staff members who have consistently given excessively high marks or extremely low marks [2, 3]. Tariq et al. introduced a more objective, criterion-referenced project assessment scheme to replace the old subjective assessment scheme [4]. The reliability of the new scheme was again studied using statistical analysis of data obtained from both the old and new schemes. Some assessment schemes use a grading category index (GCI) instead of actual mark for each assessment criterion. GCIs usually have a smaller number of options to choose from when awarding results. For
example, the GCI may give eight levels with the highest being awarded to exceptional students and the lowest being awarded to students of inadequate performance. This reduced level of categories has been shown to result in less variability between assessors compared to systems which use marking ranges between 0 and 100 [4]. Staff also find it easier to use GCI to grade each criterion. A number of studies have been performed to examine the relation between FYP assessment methods and student performance levels [5, 6]. Validity and reliability are reported as two main concepts which must be addressed when devising assessment schedules. Validity is related by Teo and Hu to ensuring assessment of the correct aspects of the work and reliability to the consistency of the marking. These two concepts have to be borne in mind as well as the distribution of the grading. In this paper, the student assessment method and performance over the last six years in engineering are presented.

METHOD OF ASSESSING FYPs
A systematic approach is suggested using statistical analysis in order to examine the final year student project performance in mechanical engineering. Project marks of the final year student project in mechanical engineering obtained from the past six years (2002-2008) were recorded and analysed. The recorded data and assessment criteria are presented in Table 1.

Table 1: Breakdown of (a) progress and presentation 1st semester marking, (b) final project report assessment, and (c) 2nd semester presentation, performance and overall mark.

<table>
<thead>
<tr>
<th>Progress</th>
<th>Interim</th>
<th>10%</th>
<th>2nd reader</th>
</tr>
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<tbody>
<tr>
<td>Sem. 1</td>
<td>Superv.</td>
<td>QP</td>
<td>40%</td>
</tr>
<tr>
<td>15%</td>
<td>2nd reader</td>
<td>QP</td>
<td>40%</td>
</tr>
</tbody>
</table>

(a)

<table>
<thead>
<tr>
<th>Final Report 50%</th>
<th>Supervisor</th>
<th>2nd reader</th>
</tr>
</thead>
<tbody>
<tr>
<td>C</td>
<td>OR</td>
<td>BG</td>
</tr>
<tr>
<td>50%</td>
<td>30%</td>
<td>20%</td>
</tr>
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(b)

<table>
<thead>
<tr>
<th>Final (Lab) Presentation 20%</th>
<th>2nd reader</th>
<th>Perform.</th>
<th>TOTAL</th>
</tr>
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<tr>
<td>QP</td>
<td>C</td>
<td>Q/A</td>
<td>Tot</td>
</tr>
<tr>
<td>40%</td>
<td>30%</td>
<td>30%</td>
<td>100%</td>
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Since performance, presentations and the final report contribute directly to the overall mark of the FYP, all of them were considered for FYP assessment. As shown in Table 1, the performances for the two semesters were considered. The presentation skills distributed between the two semesters were considered and every semester mark distributed among three parts: 1- the quality of the presentation, 2- the content of the presentation and 3- the ability of the student to answer questions directed to him at the end of the presentation. The
final report distributed among three parts: 1- the content, 2- the quality of the report and 3- the background. So the performance of the first semester, the interim presentation, the final report, the final presentation and the performance of the second semester contribute 15%, 10%, 50%, 20% and 5% respectively to the overall total. The supervisors supervised and guided the project student for the whole year. Also, another staff member who is familiar with the topic of the project was appointed as a second project assessor for presentation skills and final report in order to ensure that impartiality and consistency is preserved in marking.

RESULTS
A confidence interval gives an estimated range of values which is likely to include an unknown population parameter, the estimated range being calculated from a given set of sample data [7]. A 75% confidence interval based on the normal distribution was used to evaluate the margin of error, i.e. the range of marks that has a 75% probability of containing the marks that students have achieved. The total number of FYP students decreased for the last six years shown in Table 2. In Figure 1, a similar trend for a reduction over this period can be observed from the overall FYP marks. A FYP marks comparison between the first and second semester in terms of presentation is shown in Figure 2. This trend of marks was noted separately in the marks over the six years for the quality of presentation, the content, and in their ability to respond to questions and answers. The second semester presentation marks and were always better than the first semester results. Figure 3 shows FYP report marks for the last six years. In these figures a downward trend in terms of marks is noticed. These figures also show an upward trend with time in terms of margins of error, which indicates that the marks are becoming more widely scattered in recent years.

Table 2: Number of students in the years analysed.

<table>
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<tbody>
<tr>
<td>Number of students</td>
<td>73</td>
<td>69</td>
<td>66</td>
<td>66</td>
<td>55</td>
<td>47</td>
</tr>
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</table>

Figure 1: Average FYP marks for last six years. Confidence intervals shown were calculated using Z values for a 75% level of confidence.
Figure 2: Average FYP first and second semester presentation marks for last six years. Confidence intervals shown were calculated using Z values for a 75% level of confidence.

Figure 3: Average FYP report marks for the last six years. Confidence intervals shown were calculated using Z values for a 75% level of confidence.
DISCUSSION AND CONCLUSIONS
Upon successful completion of the project, students should be able to adhere to imposed deadlines, keep organised record activities, carry out applied research in a critical manner, communicate in a written report, give oral presentations, and have an appreciation for safety aspects [8]. The FYP in the curriculum of the academic programmes at the degree level is a major element in which the student uses their previously learned engineering skill as well as developing new skills and abilities. It is also a major element of their final degree assessment. Since the FYP mark eventually affect the career prospect of the student, standardization of the project assessment should be implemented. In this paper, the final year student project performance in mechanical engineering for the last six years was analysed using a systematic statistical approach. The outcome of this study helps to identify teachers marking and student performance trends. A downward trend in FYP marks over the last six years may be attributable to hard marking scheme. However, the authors believe that this is unlikely as the same marking methods and lectures have been in place during this period. The downward trend in the FYP results mirrors the downward trend that has been seen in the mathematical results at second level over the last ten years [9]. If it is the mathematical element that is causing a reduced level of performance, a change in the lecturing and support for the students’ mathematical elements needs to be provided to compensate for this deficiency.

REFERENCES
Soft Skills: Communication, Ethics and Entrepreneurship
EMBEDDING ENTREPRENEURIAL ACTIVITIES IN EDUCATION, PERSPECTIVE FROM PRODUCT DESIGN & TECHNOLOGY PROGRAMME

Pat Phelan and William Gaughran

Department of Manufacturing & Operations Engineering, University of Limerick
E-mail: Pat.Phelan@ul.ie

ABSTRACT
Entrepreneurial Activity has been identified in a key policy document published by Forfás as a key contributor to the challenges facing Ireland as it seeks to maintain economic growth and promote the social capital of the regions.

This presentation is based on a report prepared for the Leonardo Da Vinci Community and Vocational Education action Programme. It has also been informed by developments of a new programme of study at the University of Limerick in Product Design & Technology. This degree programme incorporates design based project activities through all four years of the programmes where the student develops a design concept and prototype with working drawings and presents these to peers, tutors, sponsoring companies, and in final year to a public event.

INTRODUCTION
Forfás, Ireland’s national policy and advisory board for enterprise, trade, science, technology and innovation published a policy document, Towards Developing an Entrepreneurship Policy for Ireland in 2007 [1]. The context for this report was the challenge to help Ireland meet a number of key challenges in both developing the both the economic well being and social capital in the regions of Ireland. Education was identified as both an enabler and driver to develop entrepreneurial culture and climate to support these goals.

The Forfás report identified entrepreneurship as a significant factor in the following challenges if Ireland’s was to maintain vibrant regions that promote economic growth and social inclusion. The knowledge economy supported by good design was seen as key component of strengthen the enterprise base, sustaining growth, and keeping a competitive advantage in the Irish economy.

SUPPORTING ENTREPRENEURSHIP
The challenge identified in the Forfás report is to enhance the entrepreneurship capacity of Irish Society through role models, positive media portrayal, and using the education system to develop
this culture [2-4]. By creating an environment where students can have the opportunity to develop their skills by sharing their ideas and experiences with both their peers and tutors in a positive environment, will enhance these students ability to develop entrepreneurial skills [5]. Society must see the merits in that risk and failure are an important element in reinforcing positive perceptions of entrepreneurial culture and must accept and value the entrepreneurial process if it is to succeed. The factors identified in the literature as contributing to the decision of people to become entrepreneurs have identified that contributing factors include economic, social, personal, societal, sense of achievement, and hard work.

The role of Regional Authorities in supporting local development has seen different models of incubation developed as a support to the new business. Economic and Social factors have been identified as key considerations for Local and Regional Authorities in relation to the developed incubator model [6]. The support varied between minimal infrastructure provision incorporating space, to active strong intervention in the business plan of the organisation. Evidence gathered by Hackett and Dilts claimed that the critical involvement of business support managers correlates with better incubator performance [7]. One of the issues with Enterprise Centres is that they promote all ideas and do not provide an effective filtering system, particularly if the entrepreneur is not willing to fully open with their business plans.

The difference between male and female entrepreneurs has been investigated by DeMartino, and Barbato 2003. A better work life balance was identified by women that had children as a primary motivator for their involvement in entrepreneurship activities. Women see the role of entrepreneur as offering flexible career opportunities. Men on the other hand see wealth creation and economic independence as primary drivers. Family responsibilities were not seen as inhibiting factors in their involvement in business.

SURVEY OF ENTREPRENEURS AND SUPPORTING AGENCIES IN THE MID-WEST REGION

Feedback from the Entrepreneurs

The characteristics identified by the entrepreneurs were established by posing a series of question and the principal findings from the discussion are summarised below. The findings are ranked in order of significance.

Personal Factors

Supporting

- One of the most significant factors in establishing a business was based on economic reasons where unemployment or reduction in earnings acted as a catalyst for people to form their own company.
- Independence, job satisfaction, ownership, esteem with peers, recognise opportunity in the market,
• Good communication skills and the ability to establish a relationship with a customer are essential to long term success.
• Non-nationals identified as a group highly likely to start their own company due to the difficulty in establishing employment record.

Inhibiting
• Fear of failure, lack of security
• Loss of regular income
• Regular working hours

Attitudes of Entrepreneurs
Supporting
• A strong sense of self-belief initiative, with a willingness to take risks and prepared to work hard were essential.
• The ability to delegate was seen as essential if the business was to expand, many entrepreneurs have specific skills that enable them to start a business, but have identified that a different skill-set was required to expand one.

Inhibiting
• Lack of focus, Lack of determination, not prepared to commit, Extremely creative-but has not enough to carry through.
• Unrealistic ideas/plans, Lack of finance, Lack of marketing, Easily deterred

Support Systems
Supporting
• Financial advice was identified as of significant importance to businesses considering expansion or changing direction.
• Identification of new opportunities and facility to establish a rapport with a suitable mentor who could provide advice on specific problems.

Inhibiting factors
• Lack of suitable space, it is necessary to have workspace in cluster area. This provides support and also enhances business opportunities with other companies.
• Bureaucracy- form filling (CSO, VAT, Taxation)
• High wage rates, employment regulations.
• Difficulty in finding suitable mentor.
• Lack of “Leave of Absence” policy as a statutory right in Irish companies.
FEEDBACK FROM SUPPORTING AGENCIES/ FINANCIAL INSTITUTIONS

- Feeling that there was a lack of entrepreneurship activity coming from students that have completed third level college. The education system seems to foster “risk adverse” behavior from the graduates.
- Depth versus breadth of education. There is an opportunity to explore more interdisciplinary education opportunities for the graduates with the stated aim of establishing entrepreneurial activity.
- Develop good communication is essential between the entrepreneur and the support agencies. In some cases additional training is necessary to formulate proposals to financial groups, and state support agencies.
- A need to counter the often negative image manufacturing sector has in the media with job losses in particular sectors giving a poor image of the sector. It was agreed that multinational closure can also be a catalyst for entrepreneurs to start their own business and create further more sustainable employment opportunities.
- Need to create a positive message among the public that starting one’s own business is a positive career move, and a positive experience.
- Opportunities to take a “Career Break” for 1 year is available in some countries particularly in the Public Sector. This should be extended to the private sector to support job creation.

EDUCATION & ENTREPRENEURSHIP

Entrepreneurship Education can be defined as the focused practice that creates the knowledge based systems that give rise to excellence in all areas [8]. One cannot treat Entrepreneurship as a speciality programme as it focuses on generic critical skills. Expert performance is developed and encouraged from Practice Based learning approaches. The exclusion of a large section of the population on the basis that these are inherent skills is incorrect.

In 2003 the University of Limerick launched a four year, Level 8 honours degree programme in Product Design & Technology. The genesis of the programme was developed in response to a National Report by the Irish Council for Science, Technology and Innovation, subsequently the Advisory Science Council to the Irish Government, which identified the whole area of Product Design as a key enabler of the SME sector in Ireland and positioning Ireland as a Design Leader. The programme was developed to meet the needs of this sector of the economy.

A key aspect of this programme was to create a positive environment where students could develop their technical, design skill, communication skills, and presentation skills which were deemed essential for graduates to be successful in design. The main aspects of this programme are developed using project based learning through:

- studio based activity promoting interaction primarily informal with peers and staff members,
- Presentation of ideas both formally and informally.
- Projects in Year 2 and Year 3 are aligned with companies who agree to sponsor prizes to best place students. By associating the students projects with real companies and business people a range of skills were developed in design, communication, and importance of dealing with and meeting company deadlines.
• Final Design Project 75% of credits in Year 4. The students present their work in a public forum where invited guests include friends, family, academic staff, business representatives, and development agencies.

CONCLUSIONS
• The findings of the survey completed in the mid-west region on the characteristics required of entrepreneurs were found to be consistent with the published literature. Both the literature and survey completed agree that initiative, self-belief and willingness to make and learn from mistakes are essential.
• Our experience to date from this degree programme is that it creates a more positive learning environment for the students. The skills developed by the graduates are consistent with those identified by the published literature and surveys as being essential for entrepreneurial activity.
• The concept of Studio based activity promoting group interactions and activity can be shared with other engineering and technology programmes. Important to celebrate student work.
• We are getting good support from both the financial, business and manufacturing sectors, in developing these experiences for the students and presenting them to the public.

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ABSTRACT
Like everything else in life, in business we have to deal with people. A successful manager will have to ‘Plan, Organize, Lead and Control’. Each of these four aspects of management requests dealing with people. In the practice of management it will always be ‘You’ and ‘Them’. To be a successful entrepreneur one requires a number of skills but success will not be forthcoming without ‘networking’. Successful networking needs communication skills. Teaching management to engineering students requires the development of their ‘soft’ skills. They need to be made aware of not only who they are as persons, what makes them tick and what their moral standpoint is but also how to interact and communicate with others. This paper will give you a flavour of a module created to impart these kinds of skills to students of Engineering Materials and Bio-Engineers.

INTRODUCTION
Recently, Neil Glover, Project Manager University Research RR plc was asked ‘What do engineering employers want from our graduates? His answer is summarized in bullet form below:

- Evidence in real interest in solving practical engineering problems
- People who can think around an issue and apply their knowledge to unfamiliar circumstances
- Evidence of applying learning through project work and planning to hit deadlines
- Bright and enthusiastic people who will fit into the team.
- Less concerned with the extent of the candidate’s taught knowledge

Clearly today’s engineering employers request that our graduates should be able to hit the ground running, possess complex creative problem solving, team working and communication skills, together with adequate knowledge and understanding of business/management issues. The challenging task for us is to seek the right balance in addressing the demands of modern industry whilst retaining our focus on the student’s intellectual developmental needs. At the Department of Engineering Materials of the University of Sheffield we have developed two modules, soon to be merged into one, that espouse exactly this challenge; MAT388 ‘Creativity, Innovation, Enterprise, and Ethics’, developed by the author and MAT381 ‘Management for Bio-Engineers’ developed by Prof. R. Short and currently also taught by the author.
This paper will provide a short description of how these modules operate, what they hope to achieve and how the students are assessed.

THE MODULES - γνωθι σεαυτον - KNOW THYSELF

“If you are not a viable unit in the ordinary world, you will not become one elsewhere. If you have poor capacity for making human contacts, we cannot offer you the substitute of a community where ‘we understand one another’. That belongs to play-life, what some, of course, generally call real life.”

From: Learning how to learn, Idries Shah.

The starting point for both modules is providing the students with the opportunity of exploring their personal learning and thinking styles [2, 3]. As individuals we are all different and we tend to have different abilities, strengths and ways of solving complex problems. The idea is to get the students to appreciate the differences that exist between themselves as well as help them identify and strengthen their weaknesses in their learning. Work done back in the 1960’s at Harvard has demonstrated that two students with nearly identical intellectual capacities can have markedly different abilities in problem solving or intellectual discourse [4].

The graphs shown at the end of this paper provide you with a flavour of the data collected. It can be seen that in general engineering students appear to be well rounded students. Of course the point of the exercise is not only to achieve personal recognition of strengths and weaknesses in our learning in order to be able to work towards future improvement more effectively but to realize that we are different and these differences can be something quite positive in team work as we all contribute different strengths to the group process.

Other researchers [5] have shown that student developmental growth relies on experiential learning opportunities coupled with reflective observation and judgment. During this part of the process the students are introduced to Kolb’s experiential learning cycle [1] and are asked to reflect and discuss their findings as part of a personal portfolio that they will compile over the course of the module. At the tail end of this work an introduction is given as to what do engineers do.

Once this introspective part of the process has been achieved, the students are introduced to the concepts of creativity, innovation and entrepreneurship. The approach is interdisciplinary, thematic and holistic. There is a ‘vision’ set out for the complete module instead of the traditional specific disciplines. Individual concepts are explored through the use of lectures, group activities, case studies and presentations by practitioners such as economists, industrialists, entrepreneurs, venture capitalists and bank managers. The structure of the module is based on interconnected themes that allow flexibility in the programme without loss of cohesion. Throughout the module the students are provided with background factual information on the financial, accounting, project management, product quality, human resources and managerial aspects of running a business in a holistic manner having spent time on introducing systems and systems thinking. The modules are rounded off by discussing ethics and ethical dilemmas through the use of case studies.

“You can learn more in half an hour’s direct contact with a source of knowledge (no matter the apparent reason for the contact or the subject of the transaction) than you can in years of formal effort.” From: Learning how to learn, Idries Shah.
THE ASSESSMENT
As already alluded to earlier each student works on a personal portfolio throughout the course of the module. That forms 60% of their assessment. In order to further develop their communication and team work skills, the students are split into groups of four, maximum five and are asked to develop a business plan for a new product or company. The groups are asked to keep minutes of all their meetings as they progress through their group projects and develop a group portfolio. In order to avoid positive or negative discrimination within the groups, members are asked to assess each other’s performance and provide explanations and reasons for their assessment. At the end of the module each group makes a presentation of their project to a panel of experts who act as potential venture capitalists who might want to invest in the group’s unique ideas.
Team work and the introduction of an element of competition between the groups seem to work very well as motivators. However, we intend to introduce some extra incentives next time round by having actual prizes for best presentation, second and third place via sponsors who are either individual entrepreneurs or industrial organizations.

THE RESULT
Feedback obtained by the various cohorts taking these modules has been in general quite positive and the modules have been continuously evolving over the years. We believe that: learning is enhanced when learners are personally engaged in the learning process and they can see the relevance of the subject to themselves and their careers; all learners are different; creative and critical thinking skills are essential for today’s global market; learning is a life long process; the need to develop their ability to transfer and apply learning to multiple situations; reflection is very important for assimilation and that the use of technology can enhance the learning process.
We are confident that the modules incorporate the complete experiential learning model proposed by Kolb and that the students are able to hone their communication skills and work cooperatively within their groupings realizing the value of team work in visualizing and implementing solutions to complex problems; the modules provide relevant, interesting and challenging learning experiences giving the students ample opportunities suitable to their particular style of learning; different aspects of learning are synthesised across multiple contexts providing the students with the opportunity to synthesise and the provision of a variety of assessing techniques allows them to take some ownership of the process.

Although students are encouraged to recognise their own learning styles and preferences but these preferences are not used to pigeonhole them in these styles but rather to reinforce the individuality of particular modes of learning and thinking. The value we see from such exercises is that the students reflect on how they learn and they use these findings as a springboard to improve on learning styles that are less comfortable with. Experimenting outside their comfort zones increases their learning experience and helps them become more rounded learners. Analyses of the ‘kite’ learning profiles of the students can act as a starting point for the lecturers by providing insights as how to best interact with their students. This is useful information for adopting teaching approaches that are suitable for the maximum number of students and also the basis for planning learning opportunities that would cater for those in the minority, e.g. small-group brainstorming activities are extremely effective for experimenter (active) learners, or brief intervals in teaching to allow the students to think through what they have been told allows the
reflective thinkers to gain the benefits. Of course this work has a positive effect on staff by making their experiences more rewarding, interesting, fulfilling and valuable. Education is both and art and a science and we believe that engaging in educational research as part and parcel of the teaching/learning process yields rewards for both learners and teachers, as well as the wider academic fraternity.

The use of a group ‘real-life’ project under tight time limits and the pressures they exert proves to be very rewarding for the students. They find the experience both frustrating and rewarding – a reflection of reality. The group project manages to bring forth all the management elements we would like to emphasise: group formation, conflict, motivation, leadership, negotiation, criticism, cooperation.

The planning of personal and group portfolios help to emphasise the project planning, communication and presentational skills. Product development or business planning brings to the fore the knowledge required for brainstorming novel ideas, divergent and convergent thinking skills, incubation (reflection), evaluation of solutions and finally verification. Students have an intrinsic desire to learn and they learn more effectively if they believe that what they are being taught will matter in their lives [6-8]. The programme, in its latest iteration, is to introduce more interactive presentations and mixed-team learning activities with a competitive element dispersed throughout the modules, culminating with short, 5 minute group presentations to peers and staff. Emotions are known to have a strong, some say dramatic, impact on learning [6]. The use of group case presentations in front of judges outside their ‘comfort zone’ raises the stakes as does the element of inter group competition. The emphasis here is on teamwork, integrity and dedication. Motivation and pleasure are the basic ingredients here; there are intrinsic rewards associated with the learning process itself but the intention is to also introduce extrinsic rewards (e.g. prizes) in the future.

Finally the assessment process provides the students with ample opportunities to express their learning in a creative non-prescriptive manner by allowing them freedom of expression. The personal portfolios are exactly what the title states ‘personal’. Although all students are given instructions as to what areas their portfolios should cover, each portfolio is different, reflecting the individuality of its owner. That sometimes creates problems for the ‘external’ examiners who would like to see more uniformity and clearly identifiable scoring scales, but after all these are modules on creativity and creativity is not uniform, it is chaotic. Another useful part of the assessment exercise is that of the students having to assess each other and providing the reasons for their choices. This is a test of what behavioural and ethical skills and awareness the module has imparted. The intention of these modules is to instil new mindsets in the students cultivating fondness for creativity and learning, in addition to building up their confidence, enthusiasm and abilities to communicate and collaborate effectively with others.

For future developments what we would like to be able to do would be more systematic analyses of the learning style and thinking style indicators data by using them at the beginning and at the end of the course and looking for any significant shifts in the patterns, as well as combining them with questionnaires of pre- and post-course surveys about the modules. Such data will provide indications as to any gains derived by the students as well as useful information on any learning pattern alterations.
“The role of the teacher is to provoke capacity in the student, to provide what there is when it will be useful, to guide him towards progress. It is not to impress, to give an impression of virtue, power, importance, knowledge or anything else”.
From: Learning how to learn, Idries Shah.

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IMPLEMENTATION OF VIDEO FEEDBACK TO ASSIST
THE LEARNING OF PRESENTATION SKILLS

Philip Smyth¹, Dermot Brabazon¹, Shadi Karazi¹, David Molloy²

¹School of Mechanical and Manufacturing Engineering, Dublin City University, Ireland
²School of Electronic Engineering, Dublin City University, Ireland
E-mail: philip.smyth@dcu.ie

ABSTRACT
This paper describes the implementation of an online video resource for both postgraduate and undergraduate students with the aim to improve the learning of presentation skills. As part of the final year project in this last academic year, presentations were recorded at the start of the second semester. These were then made available to the students during week eight of the semester over the web via student specific portal pages. The student's marks and feedback from the lecture assessors on the presentations were also made available. The students were also recorded during their final presentations at the end of the semester. The changes in student grades were examined and compared to those over the previous six years when such feedback was not available. The resource was also designed to aid lecturers to view presentations they may have missed and enter marks for their allocated students.

INTRODUCTION AND RATIONAL
This project was implemented during the 2007/2008 academic year in Dublin City University. Development began during the first semester with the design of the EngPresent software and the recording of the first set of final year project presentations. Assessment of student presentations is currently implemented in various undergraduate modules in second, third and fourth year. Students’ presentations were recorded and made available online. Although the students all present in the lecture theater in front of each other, each student’s presentation was only accessible to themselves via their own personal username and login. By having the presentation available to them they can see what was good and bad with their individual style. They can also see the lecturers marking for the various aspects of the presentation, including preparation, opening, closing, rapport, and ability to convey the technical content. Comments on good and bad aspects of the students’ performance were also provided in this feedback.

Different students have different learning styles. These include visual, auditory and kinesthetic. The provision of video learning resources has been shown to improve student learning as it targets the auditory and visual learner [1]. The provision of a variety of learning media has also been shown to engage students better than conventional single mode delivery [2].
RESOURCES AND METHODS

Presentations were recorded using a Sony Handycam SR190 which produces high quality MPEG-2 video, at a resolution of 720x576. Sound was recorded using either the built in microphone on the camera or a plug in variety that was attached to the student’s lapel. From a practical implementation point-of-view, it was deemed suitable not only to compress the video, but also to change the video format. A typical presentation video lasting 13 minutes would have a size of approximately 550 Mb. This equated to approximately 0.7Mb/sec (42Mb/minute). Even with this MPEG-2 compression, this presented some obvious dilemmas in relation to hard disk storage and web streaming. For online streaming, further compression was recommended. In order to provide a front-end Graphical User Interface (GUI) for the work SUPER (Simplified Universal Player, Encoder and Renderer) was used. SUPER is a freeware application which acts as both a player and encoder for virtually all popular video formats, [3]. This software allowed for the encoding of the presentation videos to be uploaded to the EngPresent application. EngPresent is a web application developed using Apache Struts open source framework for Java EE web applications. The format chosen was to produce the videos as Adobe Flash video files (SWF). There were a number of motivations behind this decision:

a) **File Size:** Flash video produced with Super, with a resolution of 384x288, resulted in the average file size for a 13 minute presentation of 33MB. This equated to approximately 0.042MB/sec (2.5MB/minute), or 6% of the size of the original MPEG-2 video files.

b) **Video Quality:** Despite the considerable hard disk and bandwidth savings, discernible video quality is not affected to any significant extent. Presentation text and diagrams were clear.

c) **Browser Compatibility:** Flash as a format has created market dominance, with claims from Adobe that 99.3% of all internet desktop users have the Flash Player installed. Flash is frequently preinstalled on both Windows & Mac computers (unlike both Windows Media Format and Quicktime).

A screenshot of the SUPER application is shown in Figure 1. Apache Tomcat is a Java servlet and JavaServer Pages container developed by the Apache Software Foundation (ASF). For the purpose of this project, Tomcat provides the “engine” to host the business logic of the EngPresent application. It provides a number of services such as hosting, communication, security, database connection pooling and authentication. The core business logic of the EngPresent application provides implementation for the core aspects of the EngPresent system:

a) Authentication, role management and login
b) Personalised pages for both staff and students
c) Facility for searching and viewing recorded presentations
d) Facility for viewing marking of individual presentations
Persistent data storage is handled via a pool of open JDBC connections communicating with an Oracle database. Oracle was chosen as the relational database management system (RDBMS) of choice for this project. The role of the RDBMS is to typically provide a persistent data store in tabular form. The decision to use Oracle as the RDBMS of choice was based on two principal factors: a local site license for the product and previous technical experience in deployment and utilisation. One of the more stringent requirements of the project was to provide the user interface via “thin” browser clients. A “thin client” is one which depends primarily on the central server for processing activities and principally focuses on conveying input and output to and from the remote server. Re-stating, the overall application should function on base installs of typical browsers, such as Internet Explorer, Firefox, Opera and Safari. To achieve this aim, the client user interface was developed using a combination of XHTML (eXtensible Hypertext Markup Language) and CSS (Cascading Stylesheets). For the most part, a standard install of any browser provides the platform for supporting the UI, with one important exception: video display. Video display provides some difficulties in any web-based application system. Conventional video files can be viewed in two ways: with a helper application that is launched by a Web Browser, or, when the appropriate plug-in is installed, directly in the browser’s window. The later option was chosen, with the Adobe Flash Plug-in selected for the medium of video delivery.

Once the EngPresent application had been rolled out, every student presentation was recorded, edited and uploaded for lecturers to view. This allowed academic staff to view presentations that they missed and to either grade them or gain an insight into work carried out by the student. Once all of the student marks were uploaded to the system, students could view the recording of their presentation/questions and could then see their associated results for each graded section and overall. Also students were given critical
breakdown of their presentation as a whole. Suggestions on how to improve their presentation technique accompanied this breakdown and it was hoped would lead to an improved performance in their second presentation on the same topic later on in the academic year. The marks achieved from previous years have been compared to the marks achieved with the new implementation of presentation skills learning. The presentation skills marks were expected to be higher in final year students after being trained with the new proposed method. Figure 2 shows a screenshot of the current setup of the EngPresent application. This is what the student would see when viewing his or her presentation. Information such as the presenter ID and group information is also given along the side. The overall mark is given at the bottom of the page with a link to a more in depth breakdown of the marks awarded. It is in this section that the student can view the positives and negatives as perceived by the examiner and also the suggestions on how to improve their presentation technique.

![EngPresent](screenshot)

**RESULTS**

Feedback from staff who used the system was very positive and many believe that the system had great potential to become a powerful tool for them and the students to utilise. They believed that it was a good investment to develop such an application and that
student grades would improve in terms of the quality of their presentations. Figure 3 shows the actual results for the average percentage awarded for quality of presentation only over the last six years. Diamond points represent the overall first semester presentation mark and the square markers represent the overall second semester presentation results. From this graph we can see no clear difference after the implementation of the new system in 2007/2008. The results from 2007/2008 are based on the results of 47 final year students. Further analysis with larger sets of students will need to be carried out to understand why this is so and also a larger group of students in subsequent years will be examined.

![Graph showing total average marks awarded for Quality of presentation for first (blue) and second (red) semesters for all disciplines from 2002 to 2008](image)

**DISCUSSION AND CONCLUSIONS**

Figure 4 shows the currently deployed version of the EngPresent system. There are a number of limitations associated with this implementation. Principal among these are:

1) Video recording is performed manually, involving an individual to act as videographer,
2) The data from printed marking sheets must be inputted into the system manually, involving a considerable amount of time for one individual, and
3) Video compression and conversion, while handled as a batch job through Super, involves manual file naming and uploading to the application server.

In effect, the current system provides a software front-end to what is largely a manual process. Figure 5 shows the intended next format for EngPresent. This includes a more rounded fully automated system with the compression and encoding being done on the server. In the future it is envisaged that once the presentations have been uploaded that lectures could also input their marks rather than having to send them to a systems administrator to input. Also the flash video format produced by SUPER has no facility for rewinding and fast forwarding when watching videos, which is an addition that could be examined through Flash manipulation.
Figure 4: System overview of EngPresent as it exists now.

Figure 5: System overview of future development on EngPresent.
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POSTGRADUATE RESEARCHER COMMUNICATION SKILLS TRAINING

Bob Lawlor
National University of Ireland, Maynooth
E-mail: rlawlor@eeng.nuim.ie

ABSTRACT
A supervisor-friendly model for integrating communication skills training into science and engineering research programmes is presented. The model includes five related units including communication skills (written and verbal, intra- and inter-disciplinary) and information literacy. Elements of the model have been piloted individually and feedback from these pilots has been used to refine the proposed composite module. The resulting module has been discussed in detail with heads of departments and directors of research institutes and has been broadly welcomed.

INTRODUCTION
Recent years have seen a growing recognition and general acceptance of the need for the introduction of structured generic skills training into fourth level education in Ireland [1-5]. This recognition and acceptance is consistent with international practice in fourth level education development [6-16]. Despite such a widespread development, effectively embedding and integrating generic skills training into postgraduate research programmes remains a challenge for a number of reasons such as

- Time pressure to complete the research workload can result in little or no time for generic skills training.
- Many generic skills are more conducive to experiential learning than formal training courses e.g. communication skills.
- Each student’s research programme is unique to the student and ideally generic skills training should be available at a time most appropriate to the student’s needs [4, 17], i.e. embedded in their research programme.
- Depending on the career aspirations of each individual student, different students will require different generic skills modules and these modules will require some level of customization [13, 14].

The Irish Universities Association (IUA) has played a central role in the development of 4th level education in Ireland [3] and has recently ratified a draft graduate skills statement which is due for formal release later this year. This skills statement will be a useful reference document for the development and implementation of postgraduate skills training initiatives. The IUA graduate skills statement lists the following seven generic skills categories:

- Research skills and awareness

1 Ratified on 23rd June 2008 at IUA Quarterly Council Meeting at NUI Maynooth.
Within each of the seven categories, specific skills are listed. These skill sets are largely in line with similar overseas graduate skills statements [12, 15, 16]. In relation to the IUA draft graduate skills statement, one point to note is the fact that there are elements of communication skills in all seven categories e.g. “synthesize new and complex information” under Research skills and awareness; “avoidance of plagiarism” under Ethics and social understanding; “persuade others of a viewpoint’s merits, demonstrating and communicating credible suggestions to achieve one’s aims” under Personal effectiveness/development, to list but a few. This overlapping nature of communication skills is consistent with the general acceptance that communication skills are the most important of all of the generic skills [7]. For this reason, the focus of this work is primarily on communication skills development.

RESOURCES AND METHODS
During 2007/08 the following postgraduate researcher generic skills modules were piloted in the Faculty of Science and Engineering at NUI Maynooth, under HEA SIF1\(^2\) funding:

- Information Literacy
- Communication Skills (written and verbal)
- Career Development
- Entrepreneurship

Pilot module delivery was based on a blend of face-to-face interactive workshops supported by online learning resources e.g. pre- and post-workshop reading material and moderated discussion forums [18, 19]. Efforts were made to minimize the necessary number of face-to-face workshops (typically 3 hour) and to maximize the scope for self-paced progress. Module feedback was gathered through end of module questionnaires. The pilot modules were not formally assessed. Based on the pilot modules feedback and on current international practice in postgraduate generic skills training, particularly [15], the following five ECTS\(^3\) communication skills training model was derived:

Unit 1. One ECTS credit for Information Literacy, the outcome of which will be a written literature review (draft) including a short section outlining the student’s information search strategy.

Unit 2. One ECTS credit for writing a short document (~1000 words) aimed at communicating their work to an interdisciplinary target audience.

\(^2\) Higher Education Authority – Strategic Innovation Fund, phase 1

\(^3\) ECTS – European Credit Transfer System – 1 ECTS credit equates to approximately 20 hours of student effort.
Unit 3. One ECTS credit for giving a short presentation of their work to an interdisciplinary target audience.

Unit 4. One ECTS credit for presenting their work at an appropriate forum e.g. a departmental research seminar, a national or international conference or similar.

Unit 5. One ECTS credit for writing a research paper with view to submission to a conference / journal or similar.

The attractive feature of [15] is the fact that the communication skills training is largely integrated into the student’s research programme, that is, the training ties in with work which the student is likely doing within their research programme. The reasons for combining the information literacy and communication skills were as follows:

1. Effective Communication is about information reception (reading, listening etc) as well as information transmission (writing, presenting etc). Information literacy is largely about identifying what to read (strategic searching etc) and as such is an important element of effective communication.

2. The majority of the target research students are on three-year programmes and as such are under time-pressure to complete their research workload on schedule.

3. Before students start ‘transmitting’ (writing and presenting) information they should first complete a detailed literature review of their research topic.

The five-unit module outlined above was emailed to each head of department and director of research institute within the Faculty of Science and Engineering at NUI Maynooth. This was followed up by individual interviews with the heads/directors or their nominees to capture their reaction and to discuss in detail how best to make the module adaptable to their specific requirements. Ten such interviews were conducted and the reactions were largely positive (see results below).

The module will be delivered twice (once per semester) during the 2008/09 academic year. The two deliveries will be approximately six months apart in order to give prospective students some level of flexibility as to when they access the module. Units 1, 2 and 3 will be delivered over a six-week period with one 3-hour workshop per week (two workshops per unit) plus approximately forty hours of self-paced work including reading, assignments and online discussion forum engagement [20]. Units 4 and 5 are 100% self-paced and very flexible reflecting the fact that the majority of the target research students already engage in such experiential learning activities through their research programme.

RESULTS

Although elements of units 1, 2 and 3 of the proposed module have been piloted and the successes and failures of those pilots used to develop the module, detailed results will not be available until after the first delivery of the module.
One significant result, however, was the fact that in the interviews described above, apart from minor discipline-specific adjustments, the proposed module was largely welcomed. A number of the departments/institutes suggested that preparing and presenting a poster may be appropriate as assessment elements of units 2/3 and/or 4/5. This will be accommodated in the delivery. Most of the departments/institutes have existing in-house research seminar series which would satisfy the requirements of unit 4. The most radical discipline-specific adjustment was that the mathematics department indicated that the draft literature review of unit 1 was not appropriate for their research students and suggested that an existing LaTeX course be put in its place. One head of department stated categorically that no attempt should be made to introduce generic skills training into 3-year research programmes as there simply is not sufficient time available and it would lower the quality of the research.

DISCUSSION
Despite general acceptance of the need for structured generic skills training within postgraduate research programmes, effectively and efficiently integrating such training presents a number of challenges. Issues such as the following need to be considered:

- What level of resourcing is available for generic skills training? Remember – *perfection is the enemy of progress*!
- Which generic skills modules (if any) should be made compulsory? Remember – *nothing great was ever achieved without enthusiasm*!
- How best to handle the trade-off between flexible delivery and module control.
- Are the target students on 3 or 4-year research programmes? Or indeed a mix of each.
- Are the students engaging in a Personal Development Plan (PDP) process [13,14]?
- Should the faculty prioritize some generic skills over others e.g. communication skills over entrepreneurship?
- How best to assess the generic skills modules?

Although formal assessment was not applied within the pilot generic skills modules, the general consensus was that some form of light formal assessment and certification would be disadvantageous. The opinion noted above in relation to there simply not being sufficient time available for generic skills training within a 3-year PhD research programme, while a minority one, is nonetheless valid and must be respected. Apart from a 2-day postgraduate researcher induction module, which includes aspects of health and safety, all postgraduate researcher generic skills modules are ‘highly recommended’ by Faculty but are NOT compulsory. This approach is in line with common overseas practice [11]. Faculty accepted the recommendation that the final decision as to if and when a student takes any of the other (apart from induction) available generic skills modules be taken jointly by the student and their supervisor. This decision may be influenced by the student’s scholarship funding agency e.g. some PhD scholarships stipulate that the student must engage in structured generic skills training e.g. the Health Research Board 4-year PhD scholars programmes. Further, without a structured postgraduate generic skills programme in place, higher education institutions are ineligible to apply for scholarship funding under some such programmes.
CONCLUSION
The key-point of this paper is that communication skills (written and verbal) are the most important of the recommended generic skills. Embedding and integrating communication skills training into a science and engineering postgraduate research programme is a challenge. This challenge is accentuated if the research programme is nominally of three years duration. A supervisor-friendly approach to meeting this challenge is to maximize scope for self-paced and student-directed learning in their communication skills training. In practice, this means to a large extent integrating this training into work which the student is likely doing anyway within their research programme.

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INTEGRATING ENGINEERING ETHICS AND RESEARCH SKILLS IN A FIRST YEAR PROGRAMME

Eddie Conlon

Faculty of Engineering, Dublin Institute of Technology, Dublin
E-mail: edward.conlon@dit.ie

ABSTRACT
A first year module which introduces students to the social dimension of engineering is described. The key teaching tool is the use of group projects to develop students’ learning skills. The importance of addressing the motivation for engineering students studying non-technical modules is emphasised. Data used to evaluate the module is presented. It is shown that the nature of the project undertaken affects the attainment of learning outcomes. The conclusion focuses on some shortcomings of the module and highlights the importance of appropriately structuring the learning environment to facilitate self-directed learning by early year students.

INTRODUCTION
Current debates about educating engineers have focused on the need for what is called the ‘New Engineer’ [1, 2]. The demand for the ‘New Engineer’ is reflected in changing approaches to the accreditation of professional engineering programmes. Like professional bodies in other countries Engineers Ireland (EI), previously known as the Institution of Engineers (IEI), has changed the accreditation criteria to include learning outcomes focused on ‘ethical standards’, ‘responsibilities towards people and the environment’, teamwork, lifelong learning and communication. [3: 11-12] EI has identified six areas of study including the Social and Business Context. Engineering programmes are required to ‘develop an awareness of the social and commercial context of the engineer’s work’.

There is a growing literature examining how engineering faculties can contribute to the broadening of engineering education [4]. This paper will describe a first year module which attempts to broaden the education of engineers. The module focuses on the social context in which engineers work and through the use of group projects helps student to develop their research and communication skills while at the same time developing their understanding of engineering as a social, as well as a technical, process. As such it focuses on key learning outcomes identified by EI.

I will proceed as follows. Firstly the rationale for the module is discussed. This is followed by a description of the module. Data collected to evaluate the module is then presented followed by some reflections on developing the module in the future.
RATIONALE
Given the restrictions of space it is not possible to review all the debates that arise in relation to the new engineer but we can identify two main rationales behind the demand for the new engineer [5 includes a bibliography of some of the literature]. The first centres on the need to enhance the skills of engineers highlighting the importance of acquiring non-technical generic competencies in areas such as communications, project management, leadership and teamwork. These skills are required to make engineers more effective as engineers and also because, they spend much of their working lives on management and supervisory tasks. This emphasis on generic professional practice skills can be seen as a response to changes in the organization of work resulting from increased global competition [4] and new forms of work organisation [1: 19]. The demand for new skills can be seen as part of a broader agenda in higher education focusing on what is called employability. 

The second focuses on the relationship between engineers and society. It is acknowledged that engineers have a profound effect on society and there is concern that the status of engineering is being undermined as engineers are identified with environmentally damaging technologies [2]. There is also concern that this could affect the willingness of young people to study engineering. A recent report from the Royal Academy of Engineering states: ‘The social responsibility of engineering is an important issue underpinning attitudes towards the profession’ [6: 38]. Thus engineering ethics assume importance.

In the context of engineering ethics the issue of sustainability poses a particular challenge. Many codes of ethics, including the code of EI, contain a commitment to practice and promote the principles of sustainability and while engineers are seen to be central to developing sustainable solutions many of them tend to have a narrow view of sustainability, a view that is shared by engineering students [7]. Some have argued that sustainability ‘implies cultural, social and economic restructuring simultaneously with technological restructuring’ [8: 150]. Sustainability is not just about developing appropriate technology but also requires a focus on the political, economic and social arrangements within which technology is developed and used.

Taking this into account what follows is a brief outline of the overarching approach that informed the development and structure of the module. This is being done to highlight the importance of developing a clear rationale both for staff and students as to why they need to do the kind of work that is covered in the module.

My approach is informed by three key concerns:

1. Engineering is a social process.

Engineering always takes place in a social context; it affects human relationships and involves political and ethical choices [9]. It follows that engineering ethics is not just about the values of individual engineers but must also focus on the context of their work and whether it constrains or enables a socially responsible engineering practice [5]. A focus on both micro and macro issues

1 It is regrettable that this focus on the workplace does need lead to a fuller consideration of the role of engineers in designing work for others [see 5].
2 Employability has been defined as ‘a set of achievements – skills, understandings and personal attributes – that make graduates more likely to gain employment and be successful in their chosen occupations.’ by the UK Higher Education Academy, Engineering Subject Centre. See http://www.engsc.ac.uk/er/employability.
is needed to adequately address the ethical responsibilities of the profession. The recent focus on sustainability underlines the need to integrate macro issues into the curriculum [10].

This involves a focus on broader social processes and the regulatory environment in which engineers operate. The traditional approach to engineering ethics has focused on case studies and the posing of individual moral dilemmas [11]. While case studies are used within the module (mainly as a tool to emphasise the importance of public safety and to familiarise students with the EI code) the key learning tool is a set of group based projects which focus on social issues and the public image of the profession. In the main the focus is on real world problems [12].

2. Learning and research is a social process not a discreet set of fragmented tasks.

There has been some debate on how to develop the learning skills of engineering students [4, 13]. The key distinction is between embedded and bolted on approaches. With the latter approach that skills are developed independently of core course material through specific modules focused on communications, study skills or group work. While there is explicit reference to the development of transferable skills this approach is problematic as students often fail to grasp the academic value of modules divorced from their overall teaching and learning experience [13]. This tends to lead to disengagement and the constant questioning of the relevance of these modules to engineering. A further problem is that students are often assessed on their ability to carry out a set of discreet tasks such as writing a report, doing a presentation or using the library.

With the integrated approach ‘skills are developed and taught explicitly within the core discipline and the same amount of emphasis is placed on the development of transferable skills as technical abilities’ [13: 21]. Explicit reference is made to the value of developing such skills and opportunities are provided for students to reflect on their abilities and hopefully develop. This seems particularly important given the emphasis on examinations and the recitation of facts in secondary school education.

The focus in the module is therefore to integrate learning skills as part of a process of examining a real world engineering problem linked to the course content. This encourages the students to engage in problem solving and see learning as an integrated process involving defining their problem using concepts presented in the lectures, devising a strategy for collecting information to help them solve it, collecting and evaluating the information they find, arriving at conclusions and recommendations in light of their objectives and presenting these to others. The benefits of group work have been well documented [19]. By working in a group they see that learning can be a collaborative process.

The emphasis is on structuring the learning environment so that students have to engage on an ongoing basis with their project. This is consistent with a growing emphasis on active learning in the engineering curriculum [14].

3. Student motivation needs to be explicitly addressed

Reflecting on many years work in trying to broaden the education of technical or vocationally oriented students I have come to see the importance of explicitly addressing the issue of student
motivation particularly for early year students. This requires a focus on where the students are now rather than where they might be when they graduate. It involves an explicit focus on the various dimensions of engineering practice and an understanding that many engineering students tend to be active rather reflexive learners [15] and that early year students tend to have a ‘sensing mode of perceiving’ which emphasises the concrete, practical and the immediate. Such students tend to learn better using a practice-to-theory approach rather than the more traditional theory-to-practice route [16].

In general my concern is not to focus narrowly on employability but rather to broaden the students understanding of what makes a good engineer whilst at the same time developing learning skills. It is assumed that social responsibility is central to good engineering practice [9]. Thus students should be introduced to key ethical issues in the first year of their studies so that they come to see them as inherent to engineering and come to see engineering as a social as well as a technical process.

THE MODULE
The module is a 5 credit module in Professional Development (PD) delivered to the Common First Year (DT025) in Engineering in DIT, Bolton St. Typically there are 120 students who have in excess of 400 points based on their Leaving Certificate scores. The class is predominantly male with females numbering between ten and fifteen every year. The module has been in place for many years as part of a suite of General Studies modules provided within the faculty. These modules tended to cover a wide range of often unrelated topics.

I have been teaching the module for four years and it has evolved from two one hour lectures a week to one hour lecture plus a workshop/tutorial. The class is divided by eight for the purposes of the workshops which are conducted by myself and another lecturer. The module runs over two semesters. Assessment is divided evenly between an exam and course work. The latter involves an individual report written by each student and a group presentation.

The lecture programme covers three broad areas:

1. The nature of engineering and the requirements of the New Engineer. Given the importance placed on student motivation above students are given an opportunity in the first four lectures to explore the reasons why engineers need a broad range of knowledge and skills. A wide range of research findings are presented to students and the impact of engineers on society are explored. Students are required to read the introduction to Beder’s The New Engineer and write a summary before this sequence of lectures ends. This is used as an opportunity for us to evaluate the general writing skills of the students.

2. Engineering and society. Key themes covered here are the nature of communications, the public image of engineering, engineering ethics and principles of sustainability.

3. Engineers in organisations. This section of the course looks at issues within organisations including employment relations.

The workshops run alongside the lectures and are used to help the students complete a group based project on one of the themes outlined in Table 1.
While the projects are on specified topic areas it is left open to the students to define their own objectives and decide on the actual content. Each group are asked to produce a number of pieces of work:

1. An outline plan and a reading list
2. An individual reports covering the topic area. This is used to illustrate their background research and to allow us assess their writing skills. This is completed at the end of semester 1.
3. A group presentation using Power Point. This is done towards the end of semester 2.

<table>
<thead>
<tr>
<th>Table 1: The Group Projects</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. The Department of the Environment is worried that engineers are not taking the threat of Global Warming seriously. It asks your group to prepare a presentation to convince engineers that it is a serious problem and that they have a responsibility for it. You are also asked to suggest some ways in which engineers can reduce global warming.</td>
</tr>
<tr>
<td>2. Engineers Ireland is concerned that engineering students do not take engineering ethics seriously. They ask you to produce a presentation which will convince engineering students that ethics are essential in engineering.</td>
</tr>
<tr>
<td>3. The Green Party is concerned about the damage that engineers are doing to the environment. It asks your group to produce a presentation, for presentation to engineers, highlighting the environmental damage caused by engineers and suggesting ways engineering could be more environmentally friendly.</td>
</tr>
<tr>
<td>4. Engineers Ireland is worried about the image of engineering. It asks your group to prepare a presentation highlighting the positive contribution engineers make to society. It wants your group to highlight aspects of engineering that might attract more women to the profession. The presentation is to be given to secondary school students.</td>
</tr>
<tr>
<td>5. Engineers Ireland is worried that many engineers do not have the necessary skills to be successful in their profession. It asks your group to prepare a presentation for employers highlighting the skills needed for the New Engineer. It wants also asks you to suggest how engineers might acquire these skills.</td>
</tr>
<tr>
<td>6. Dublin City Council is in despair about the traffic problems in Dublin. It asks your group to prepare a presentation for engineers suggesting how they might contribute to solving the problem. It asks you to clearly identify which branches of engineering can make the biggest contribution to solving the problem.</td>
</tr>
<tr>
<td>7. The Environmental Protection Agency is concerned that engineers do not fully understand the concept of Sustainable Development. Your group is asked to produce a presentation explaining sustainable development and the role engineers can play in supporting sustainable development. Your presentation is to a group of older engineers.</td>
</tr>
</tbody>
</table>

Each group is also asked to keep a minute’s book and draw up a list of ground rules shortly after the group is formed. Group formation is based on students completing the Belbin test for group roles. It should be noted that educating the students about teamwork is not the central objective of the module. Rather groups are used as a convenient way to manage the large number and also to introduce the students to collaborative learning.

In the course of the workshops each group is also assigned an ethics case study which they present to their workshop group. These are focused on public safety and also address issues to do with working in organisations. The students are asked to apply the EI code of ethics to the case study. These presentations are short and serve a role in giving the students an opportunity to do
a presentation, often for the first time. Students are not marked on the case study presentations but participation is compulsory. Those who do not attend have a 10% reduction applied to their overall mark for the project work. The sequence of the workshops as run in 2007/8 is presented in table 2.

<table>
<thead>
<tr>
<th>Week</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>Introduction</td>
</tr>
<tr>
<td>4</td>
<td>Group Formation: Belbin</td>
</tr>
<tr>
<td>5</td>
<td>Project Planning: Stages in Doing a Project</td>
</tr>
<tr>
<td>6</td>
<td>Information Retrieval: Using the library</td>
</tr>
<tr>
<td>7</td>
<td>Review Week</td>
</tr>
<tr>
<td>8</td>
<td>Making Groups work: Ground rules</td>
</tr>
<tr>
<td>9</td>
<td>One from each Group to report on objectives and outline</td>
</tr>
<tr>
<td>10</td>
<td>Referencing and Plagiarism</td>
</tr>
<tr>
<td>11</td>
<td>Report Writing</td>
</tr>
<tr>
<td>12</td>
<td>Report Writing: Sample</td>
</tr>
<tr>
<td>13</td>
<td>Review</td>
</tr>
</tbody>
</table>

**Christmas**

<table>
<thead>
<tr>
<th>Week</th>
<th>Activity</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Presentation Skills</td>
</tr>
<tr>
<td>2</td>
<td>Presentation Skills/Report Feedback</td>
</tr>
<tr>
<td>3</td>
<td>Using PowerPoint</td>
</tr>
<tr>
<td>4</td>
<td>Ethics Case Studies</td>
</tr>
<tr>
<td>5</td>
<td>Ethics Case Studies</td>
</tr>
<tr>
<td>6</td>
<td>Work On Presentations</td>
</tr>
<tr>
<td>7</td>
<td>Work On Presentations</td>
</tr>
</tbody>
</table>

**Easter**

<table>
<thead>
<tr>
<th>Week</th>
<th>Activity</th>
<th>All of relevant group to attend</th>
</tr>
</thead>
<tbody>
<tr>
<td>8</td>
<td>Presentations</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td></td>
<td>Feedback</td>
</tr>
</tbody>
</table>

As can be seen from table 2 all stages in completing the project are covered in the course of the workshops. The module is also supported by:

1. A WebCT site which includes lecture and workshop support material but also has a projects area with readings and links related to each project topic. This has grown from year to year as students find new and useful sources.
2. A specially designed interactive session on using the library.
3. A dedicated Guide to Report Writing. Students are required to use the Guide and sign a pledge saying they will not engage in plagiarism.
4. Clear instruction sheets for each task.
5. Extensive individual and group feedback.
EVALUATION

In this section results of a survey completed by 85 of the 115 2007/8 students (a response rate of 74%) are presented along with some reflections. Table 3 presents data from students on the extent to which the module helped them in relation to a number of learning outcomes. Responses were based on a five point scale with 1 being a little and 5 being a lot. Responses are ranked from the lowest to the highest.

Table 3: Evaluation of Learning Outcomes

<table>
<thead>
<tr>
<th></th>
<th>Mean n=85</th>
<th>Std. D</th>
<th>Male n=72</th>
<th>Female n=13</th>
</tr>
</thead>
<tbody>
<tr>
<td>Find information in the library</td>
<td>2.86</td>
<td>1.07</td>
<td>2.96</td>
<td>2.31</td>
</tr>
<tr>
<td>Understand the principles of sustainable development</td>
<td>3.05</td>
<td>0.96</td>
<td>3.07</td>
<td>2.92</td>
</tr>
<tr>
<td>Working in a group</td>
<td>3.13</td>
<td>0.90</td>
<td>3.17</td>
<td>2.92</td>
</tr>
<tr>
<td>Reference information properly</td>
<td>3.33</td>
<td>1.05</td>
<td>3.35</td>
<td>3.23</td>
</tr>
<tr>
<td>Do research</td>
<td>3.39</td>
<td>0.93</td>
<td>3.46</td>
<td>3.00</td>
</tr>
<tr>
<td>Understand the role of engineers in society</td>
<td>3.55</td>
<td>0.88</td>
<td>3.57</td>
<td>3.46</td>
</tr>
<tr>
<td>Do presentations</td>
<td>3.73</td>
<td>1.03</td>
<td>3.71</td>
<td>3.85</td>
</tr>
<tr>
<td>Understand ethical issues in engineering</td>
<td>3.73</td>
<td>0.91</td>
<td>3.74</td>
<td>3.69</td>
</tr>
<tr>
<td>Write reports</td>
<td>3.74</td>
<td>0.92</td>
<td>3.81</td>
<td>3.38</td>
</tr>
</tbody>
</table>

The following issues arise from the data:

1. It can be noted that in all cases the means for males were higher than for females except in one instance: ‘doing presentations’. The differences though were not statistically significant.

2. It can be seen that the highest scores were related to understanding ethical issues in engineering and writing reports and doing presentations. This is not surprising as these three issues are given most prominence in the module. All students do a presentation on an engineering ethics case study. In open-ended responses students were most likely to say that these three items were either the ‘most interesting’ or the ‘most useful’ part of the module. Indeed in the questionnaire a number of respondents suggested that they should be given more opportunities to do presentations.

It is worth noting that outcomes related to the end product of the process, reports and presentations, score better than those to do with the process of doing research, finding information and working in a group.

3. Those that scored lowest were related to using the library and referencing, working in a group and understanding the principles of sustainable development. This again is not surprising. Although the students are given a comprehensive introduction to the library it is the case that most of the research they do is web based. It may be the case that they are using the library’s online resources without ever being ‘in the library’. The WebCT site also contains a lot of reading material.

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3 The wording of this item is problematic given the changing role of the library and its function as a portal to various online resources.
4. The issues related to working in a group are a difficulty which needs to be addressed. In an open-ended question on the questionnaire some students indicated a need to deal with ‘slackers’. Given the numbers in the module it is proving quite difficult to arrive at a system for successfully monitoring the activity in the groups. When difficulties are brought to the lecturers’ attention they are addressed. Minutes books have been taken up and examined but do not seem to adequately reflect the differential effort put in by different students. It is the case though that when it comes to evaluating assessments it is clear who has and who has not done the work. Students get an individual mark for their report and a proportion of the group presentation marks are assigned for individual contributions. Extensive questioning at the end of the presentations also helps with finding out who has done most.

As indicated above educating students about teamwork is not a key objective of the module. But the students on the module do work in groups and the issues noted above are common problems associated with facilitating groups [20,21]. Therefore it is important that we explore ways to improve their experience of working in a group by facilitating ‘positive interdependence’ [20].

5. The final item where the mean was relatively low was ‘Understand the principles of sustainable development’. This is perhaps one of the most difficult sections of the lecture programme. It also does not help that attendance at lectures is low with on average only 50% of students attending each lecture. (There are only minor problems associated with attendance at the workshops).

Significant differences on this item and on the other substantial knowledge outcome, ‘Understanding ethical issues in engineering’, were recorded when the means were compared based on the project that the students had completed.

In relation to sustainability the two projects focused on sustainability and the environment (projects 7 and 3 in table 1) had significantly higher (\(p=.05\)) means than most other projects particularly those focused on the ‘Image of engineering’ (project 4) and ‘engineering skills’ (project 5). Surprisingly there was also a significant difference between those who has done the environment project and those who had done the project on global warming (project 1) or the ethics project (project 2).

In relation to the ethics outcome the highest means were for students who had done either the ethics (2) or environment (3) project. In the case of the ethics project the means were significantly higher than the means for all other projects. In the case of the environment project the means were significantly higher than all other projects except for the traffic project (6).

It is worth noting that some of the best projects were those completed by groups doing projects 2 or 3. These groups showed a greater ability to integrate theory from the lectures with the information they had gathered to complete their project.

6. It is worth noting that 86% of respondents said that the module ‘helped them to understand what engineering is’ while 56% said it ‘changed their understanding of engineering’.
DISCUSSION

This module provides a significant opportunity to first year engineering students to develop their research and learning skills while at the same time gaining an insight into engineering as a social process which involves ethical issues. As part of a process of completing a group project students complete a number of assessments aimed at encouraging them to engage in independent self directed learning. This module represents a significant development in the broadening of the first year education of our engineering students. The extent to which the module works is related to the manner in which learning skills are embedded and engineering issues and student motivation are addressed directly.

While some shortcomings of the module have been highlighted above I want to conclude by addressing two key issues which arise from the data and from my own reflection on the operation of the module over a number of years.

Firstly it has been seen that there are differences between students, depending on the project they completed, in the extent to which they believe they have acquired an understanding of ethical issues in engineering. This is a key learning outcome of the module. Some projects seem to be less successful in helping students meet this learning outcome. Two projects in particular, ‘Image of engineering’ (project 4) and ‘engineering skills’ (project 5), scored relatively poorly on the two substantial knowledge outcomes relating to ethics and sustainable development.

There is a sense that the module is carrying some baggage from its origins as a General Studies module which often had multiple (if sometimes undefined learning outcomes). This is reflected in the wide range of topics covered in the lectures and consequently by the projects. It was hoped that projects focusing on the skills of engineers and the image of engineering would force students to examine the ethical dimensions of engineering but this has not happened to the extent expected. The students do see, for example, that the kinds of problems engineers solve and the manner in which they solve them affects the image of engineering. What they do not see is how ethical issues are implicated in these choices.

It also seems to be the case, particularly with the project on Global Warming and to a lesser extent the project on traffic, that projects focused on contemporary issues may be approached as purely factual projects without the need to integrate theoretical issues raised in the lectures. The students do not, for example, see the need to situate the information they gather about Global Warming in wider discourses about sustainability and social responsibility. Further, the students do not see the need to argue for proposed solutions and present evidence as to why one solution is better than another.

Secondly, this points to what I perceive as a difficulty the students have in engaging in self-directed learning. Part of this problem is their failure to read systematically around their topic and as suggested above integrate theory into their projects. This has something to do with their experience of secondary education [22], that fact that many engineering students are active learners and with the nature of the knowledge students, particularly first year students, engage with in engineering programmes. In scientific and mathematical modules they tend to learn that there is only one right answer to the problems they are set [19: 65, 14: 351]. The material dealt with in the PD module is of a different character. As Porra says, in discussing engineering ethics: ‘The inexact and relative nature of some of the concepts in these subject areas is in conflict with the “exact” world of technology’ [18: 337]. The students may therefore find it harder to manage
their learning in this module and know what amounts to a ‘right answer’. Their focus is very much on gathering information rather than integrating knowledge and information.

In light of these two issues there is a requirement to firstly reconsider the project topics and the lecture programme and develop new projects which will raise ethical issues more clearly and secondly, to be more directive in terms of what students need to do to complete their projects successfully. More effective goal setting may help them manage their learning better [22]. This will include a much clearer requirement to situate their project topic in the context of the lecture material. This will require greater attendance at lectures. It may require that they read set readings rather than searching widely for material of variable quality. It might be the case that by more tightly structuring the learning environment the students may learn to be better independent learners.

ACKNOWLEDGEMENT
I want to acknowledge the assistance of Marion Fitzmaurice who read an earlier draft of this paper.

REFERENCES
AN INSPIRING AND INNOVATIVE APPROACH TO PROFESSIONAL STUDIES

Jonathan Cole¹ and John Copelton²

¹ School of Mechanical and Aerospace Engineering, Queen’s University Belfast
² Careers, Employability and Skills, Queen’s University Belfast
E-mail: j.cole@qub.ac.uk

ABSTRACT
The Aerospace Professional Studies course has been developed to prepare aerospace engineering undergraduates for the professional engineering world. The course provides a good balance between professional engineering (examples of current challenges and projects within industry) and professional development (skills, career preparation). Significantly, the course is delivered mainly by external speakers representing leading aerospace companies such as Airbus, Bombardier, British Airways and Thales Air Defence. The speakers offer a range of interesting perspectives including those of director, manager, airline captain and recent graduate. Active learning is encouraged and meaningful interaction occurs between students and speakers. Assessment is based on coursework – two technical reports, CV preparation, a PowerPoint presentation on an aerospace company, and an aptitude test – which is relevant and useful. Students’ report writing and presentation skills are improved. It is believed that this course enhances the student learning experience. Students have remarked that they enjoy the course, appreciate its relevance, and gain in confidence. The course is effective in preparing and informing the students regarding the wide range of opportunities available to them when they graduate.

INTRODUCTION
This article describes an innovative and exciting course, Aerospace Professional Studies, which aims to prepare aerospace engineering undergraduates for the professional engineering world. The coordinator, Dr Jonathan Cole from the School of Mechanical and Aerospace Engineering, has worked closely with Dr John Copelton from the University’s Careers, Employability and Skills unit in developing the course which has existed in its current form for six years. The course is compulsory for students in Stage 3; about half are in their final year (BEng pathways) and half are in their penultimate year (MEng pathways).

Aerospace Professional Studies provides a good balance between professional engineering and professional development. On completion of the course, students should

- appreciate some processes and practices currently used in industry
- be more aware of the local aerospace industry
- recognise what a graduate engineer might expect in an industrial position
- have developed effective presentation, report writing and career management skills
The course is delivered mainly by external speakers representing many of the leading companies in the aerospace engineering sector, including Airbus, Bombardier, British Airways and Thales Air Defence. The speakers provide a range of perspectives, including those of director, manager, airline pilot and recent graduate. The emphasis throughout is on active learning with the students encouraged to engage with the invited speakers and ask plenty of questions.

**COURSE CONTENT**

Typically, there is a 2-hour lecture slot each week for ten weeks during the autumn semester. The following gives an outline of last year’s programme.

In the first week, the coordinator introduced the course and explained its aims. He gave a talk on technical report writing; students are required to produce two such reports as part of their assessed coursework.

In Week 2, a director from Thales Air Defence discussed the technical, commercial and strategic challenges facing an engineer, using recent projects as illustrations.

A series of career preparation talks followed. Dr Copelton introduced this series and described how to prepare a professional CV.

An engineer from Bombardier Aerospace described interview skills and detailed what a typical engineering employer desires in graduates.

A recent (1999) Aerospace Engineering graduate of Queen’s University Belfast (QUB), now at Airbus UK, recounted his progress from QUB to Airbus, and outlined his development within Airbus. A question and answer session ensued with much student input. Since the guest speaker is not much older than the current students, and followed the same degree course, the students can relate well to him and should gain confidence that they could be just as successful. Another recent graduate (2003), who worked for Qinetiq before moving to CDE Ireland, discussed aptitude tests and related his career development and experiences.

A typical assessment centre exercise was led by three engineers from B/E Aerospace during which the students worked in teams to solve a given problem before reporting their findings. Exercises such as this are hugely valuable in preparing the students for the process of obtaining a graduate job.

Two weeks were devoted to presentation skills. In the first week, Dr Copelton gave a workshop involving a combination of teaching and student participation. In the following week, the students gave assessed presentations, using PowerPoint, in front of the rest of the class.

The remaining two weeks of classes were given by a British Airways captain (another QUB Aerospace Engineering graduate). He provided advice for those interested in becoming a pilot, described the contribution engineers make to commercial aviation, and gave a fascinating insight into his job using many colourful examples from his experience.
The programme varies slightly from year to year. Another guest speaker, unavailable in 2007, works for Unilever, a company not associated with aerospace. However, he also is a QUB Aerospace Engineering graduate and has been employed by Unilever since graduation. This talk is useful for those who do not necessarily want to work in the aerospace field. The students were shown that they have many skills which are valued and applicable in other areas of engineering.

ASSESSMENT
Assessment is entirely by coursework and involves two technical reports (based on material presented by two of the guest speakers), CV preparation, a PowerPoint presentation and an aptitude test. The subject of the PowerPoint presentation is an aerospace company – the students choose a company and are asked to report on its structure, products and recruitment procedures. This element was introduced to ensure that the students are familiar with a wide range of potential employers and are in a position to make informed career choices. Therefore, the coursework is relevant and useful. Students’ report writing and presentation skills are developed. Students are offered written feedback on their first report, augmented with verbal explanation on an individual basis, they receive a corrected/improved CV, and are also given written comments on their presentation.

STUDENT LEARNING EXPERIENCE
Student feedback indicates that they appreciate the relevance of the course, enjoy the speakers, and gain in confidence. This is important as they will soon be graduating. A relatively high attendance at the classes is common – last year attendance averaged 87%. A selection of student comments is listed below.

“Was positive to see employees from such highly regarded companies taking time out to visit”
“Relevance to reality (real people with real aerospace jobs)”
“Gives us hope of actually finding a job”
“The assignments had a real life application and purpose and this made more enjoyable to complete”
“CV / interview / assessment centre stuff very useful”
“Content was interesting and relevant”
“Helps the student understand how useful his degree is”
“Very practical giving an insight to career opportunities”
The pilot’s “lectures were inspiring”
“Very beneficial and confidence building”
“Motivated us into thinking about career opportunities”

The University presented a teaching award to the coordinator, in part for his development of this course. The judges commented, “His carefully planned use of guest speakers provides the students with an enjoyable and effective learning experience, evidenced by his student evaluations.”
The course featured in a Higher Education Careers Service Unit report on credit-bearing careers education [1]. It could serve as a model for other Schools and could easily be adapted. In Aerospace Engineering, it goes a long way to achieving the University aim of providing students with the opportunity to develop career management and employability skills.

CONCLUSIONS
The Aerospace Professional Studies course for third year aerospace engineering undergraduates at QUB is a good example of how careers, employability and skills can be integrated into an effective learning experience within an academic module. The course offers a good balance between professional engineering (current challenges and practices within industry) and professional development (skills, career preparation) and features very willing contributions from many leading aerospace companies, including Airbus, Bombardier, British Airways and Thales Air Defence. The guest speakers are chosen carefully to provide a variety of interesting perspectives. For example, some graduated from QUB relatively recently and can therefore be easily related to by the current students. It is significant that much of the professional development material is presented by the industrial speakers. Active learning is emphasised with meaningful interaction occurring between students and speakers.

Assessment is based on coursework which is relevant and useful. Students’ report writing and presentation skills are developed.

Feedback from students has demonstrated that they enjoy the course and appreciate its relevance. Aerospace Professional Studies successfully educates and prepares the students regarding the wide range of opportunities open to them when they graduate. It could serve as a model for other Schools.

REFERENCES
IT in Engineering Education
EDUCATIONAL TECHNOLOGY AND THE REFLECTIVE ENGINEERING EDUCATOR: A HIDDEN VOICE

Larry McNutt

School of Informatics and Engineering, Institute of Technology, Blanchardstown, Ireland.

E-mail: larry.mcnutt@itb.ie

ABSTRACT

The purpose of this paper is to review current developments in educational technology within engineering education questioning why we do what we are doing? In a climate where we continue to witness the ongoing decline in interest in Science, Engineering and Technology courses as evidenced by CAO figures and the accompanying media headlines heralding the demise of engineering. This however is not a uniquely Irish development – the Japanese Universities refer to it as “rikei banare” or “flight from science”. The Japanese Ministry of Internal Affairs estimates that the digital technology industry has a shortage of half a million engineers [1].

In this debate largely hosted by the popular print, radio and TV media outlets, the voice of the academic engineering community is often absent. Also reflected on the global media stage where engineering role models are in short supply. Is the academic engineering community allowing its future to be determined by default? [2]. Engineering is not seen as media friendly – yet at the heart of every innovation (and innovator) presented at today’s symposium lie values, motivations and beliefs that are at their core concerned with the needs of today’s engineering students. Or as commented recently – engineers do things for people and educational technologist explore how IT can make things possible for people in higher education [3].

So how can we encourage educational technologist to give voice to the values and beliefs that motivate their work? This paper will outline experiences to date with www.mosceal.com* an initiative to encourage academics who use educational technology to tell their story.

REFERENCES


*Enrolment key for www.mosceal.com is “believe2008”
ONLINE LABS FOR DISTANCE LEARNERS: REFLECTIONS FROM AN IRISH PILOT STUDY

Eamon Costello¹, Seamus Fox² and Theo Lynn³

¹,² Oscail, Dublin City University, Ireland
³Business School, Dublin City University, Ireland
E-mail: eamon.costello@dcu.ie

ABSTRACT
This presentation discusses the introduction of remote online laboratory (lab) work into Communications Technology modules of an undergraduate BSc. in Information Technology (IT) by distance learning. The role of online labs and virtual instruments in undergraduate education is discussed and how they relate to physical labs. Outcomes are presented of a pilot introduction of online virtual labs. An argument is made that the introduction of online virtual lab work is worthwhile. We also argue it is increasingly feasible if suitable tools can be inexpensively sourced, such as from digital learning repositories as described here.

INTRODUCTION

Oscail, Distance Education Centre, in Dublin City University provides three undergraduate degrees and three postgraduate degrees by distance. For over thirty years, Oscail has presented traditional distance education programmes. However, over the past decade it has been converting these to online programmes. Increasing use is being made of Internet technologies in the delivery of Oscail’s BSc in Information Technology (IT) programme. There are four subject strands within the programme: Computing; Communications Technology; Human Science and Management Science. Each stream has four modules at successive levels of progression. Each module is 15 ECTS credits at level one and two, and 20 at level 3 and 4. A module runs over an entire academic year. Students progress through successive modules in each stream until they can take electives close to completion of the programme. The Communications Technology (CT) stream introduces students to the basics of electricity and electrical circuits and then the basics of digital technology and digital logic circuits. Most of this material is covered in the first module, called CT1, with some overlapping into its successor module called CT2. It should be noted that although this subject matter comes from fields of engineering, the programme is designed to produce IT graduates, rather than engineers.

The programme is delivered online through Moodle, an open source virtual learning environment (VLE). Within Moodle, students access course materials in PDF form for printing or reading online, and resources such as useful web links. Students may attend optional tutorials at weekends. Students are assigned online tutors who are available to answer questions, and encourage and moderate student discussion of the course content. Assessment is via continuous assessment and examination. The continuous assessment
consists of three assignments which students submit throughout the academic year. There is also an end-of-year examination.

Previously, physical access to lab sessions was offered to students but was suspended due to low demand. Mandatory attendance was deemed infeasible due to the diverse geographic location of students. (It is a goal of all distance education programmes to keep mandatory attendance to the absolute minimum.) This paper describes a pilot project which aims to address this deficiency, with regards to access to physical labs, by using virtual labs delivered online through the Moodle VLE.

**EXPERENTIAL LEARNING AND SIMULATION**

Experiential learning shares ontological root with active learning or those learning theories that assume students are both self reflective and engaged as participants in their interactions with the world. Kolb describes learning as a cycle involving experiencing, interpreting, generalising, applying, and testing [1]. The purported benefits of experiential learning are widely reported [2]. They include changing cognitive structures, altering attitudes, and expanding portfolios of skills [3].

Distance learners can be disadvantaged compared to campus-based ones. Although information and communications technology is closing that gap (and blurring the distinctions between modes of education e.g. increased us of VLEs) challenges remain to provide the distance learner with the rich learning environment enjoyed by his/her on-campus counterpart. Specifically, distance learners suffer from lack of physical access to equipment and laboratories and the associated benefits of direct interaction and experience. The alternative is simulation. Cruickshank defines simulations as “the products that result when one creates the appearance or effect of something else” [4]. Laurel claims that:

> “Educational simulations (as opposed to tutorial and drill-and-practice forms) excel in that they represent experience as opposed to information. Learning through direct experience has, in many contexts, been demonstrated more effective and enjoyable than learning through ‘information communicated through facts’. Direct, multi-sensory representations have the capacity to engage people intellectually as well as emotionally, to enhance the contextual aspects of information, and to encourage integrated holistic responses.” [5]

The use of multimedia simulations may boost curiosity, creativity, and teamwork [6]; increase learning retention and transfer [7][8][9]; provide more consistent course delivery [10]; and improve attitudes towards learning [11].

**ONLINE LABS FOR DISTANCE LEARNERS**

This paper focuses on the use of laboratories in undergraduate education. Ernst summarises the benefits of such use as:
“First, the student should learn how to be an experimenter. Second, the laboratory can be a place for the student to learn new and developing subject matter. Third, laboratory courses help the student to gain insight and understanding of the real world.” [12]

Feisel and Rossa cite thirteen fundamental learning objectives for laboratories derived by the Sloan Foundation: Instrumentation, Modelling, Experimentation, Data Analysis, Design, Learning from Failure, Creativity, Psychomotor Ability, Safety, Communication, Teamwork, Ethics and Sensory Awareness. These objectives not only are consistent with Ernst but do not distinguish between the physical and the virtual [13].

There are two types of labs where students may not be physically present with equipment in a room. Remote Labs (RL), also referred to as Virtual/Remote Instrumentation, allow participants to remotely control some tool with which to conduct experiments from which they are geographically removed. By contrast Virtual (or Online) Labs have no physical component and everything is simulated through software and accessible over the internet. It is this second type with which we are concerned here and take online/virtual labs to mean not only the use of simulation software but also that it is being accessed remotely (and not in a supervised environment where students and tutors are physically present).

Consistent with general research relating to multimedia simulations, research on virtual laboratories are encouraging. Hall finds no advantage to having a physical lab element [14]. However, others find against completely virtual systems in favour of remote instrumentation [15][16]. Abu et al. do not draw significant distinction between completely virtual and remotely operated equipment, and report success with their sophisticated virtual instrument system for power engineering [17]. Some researchers worry that students may not be able to make as many mistakes in a virtual environment and have less scope for trial and error learning (or may be more blasé in a virtual environment while conducting experiments which would be dangerous in the physical lab) [17]. One suggestion is that software labs may be used to train students prior to their introduction to the physical lab [17]. Nedic, Machotkd and Najhlsk credit the popular LabView software from National Instruments with greatly reducing the effort required to build online labs, leading to the explosion in their use and also discuss bespoke lab tools including their own [18]. Their evaluation claims online labs as low cost, relative to physical or remote ones. However others have cited the cost of LabView as a motivation for developing bespoke systems. Although software development of educational labs allows for very detailed instructional design, a significant time and labour cost is incurring before licensing costs are even considered. An alternative is to try and reuse existing systems. This issue will be returned to below.

USING ELECTRICAL AND LOGIC CIRCUIT BUILDERS IN A DISTANCE LEARNING COURSE

For the CT1 (43 students) and CT2 (37) modules of the BSc in Information Technology programme two online virtual simulations were selected to pilot in the presentation that ran from September 2007 to May 2008. These resources were sourced by the authors
from the Global Grid For Learning (GGFL), a federated digital learning repository to
which access was granted via the Learning, Innovation and Knowledge Research Centre
(LiNK) at Dublin City University. GGFL, an initiative of Cambridge University Press,
brings together disaggregated resources (including SCORM learning objects, video,
audio, image and text files) in one global service offering access to content from several
thousand sources worldwide. The resources selected, Digital Logic Builder and Electrical
Circuit Builder, were originally conceived and developed for use by students as part of
the UK National Learning Network programme. Permission was received from GGFL to
use the resources for research in teaching purposes.

Digital Logic Builder is an interactive multimedia simulation which allows students to
drag logic gates onto a grid and specify inputs into a circuit. Similarly, Electrical Circuit
Builder allows students to create circuits by dragging components such as lamps,
switches, resistors and wires onto a grid. Values can be specified for the power source
and each resistor and a multimeter can be attached to two points on the circuit to measure
currents. The lamp glows brighter when it is using more energy and its filament will blow
if the lamp’s amp rating is exceeded. A guide to using both tools is available. GGFL
make the resources available as IMS content packages with SCORM 1.2 runtime
capability [19]. The version of Moodle (1.7) used by DCU provides for the import of
SCORM/IMS content packages however it was decided to embed the simulations directly
in to Moodle as the data persistence features of the software provided by SCORM were
not needed and the method Moodle used to integrate SCORM resources may have caused
unnecessary confusion to students.

A lab tool was integrated into one module as part of continuous assessment i.e. its use
was mandatory. Students were required to build an electrical circuit with specific
characteristics and then take a screen shot of it and include it in their answer. The
students then discussed this assignment online in Moodle discussion forums, monitored
by an online tutor. While there was one instance where access was prohibited due to
browser security settings, the few implementation issues that arose could be described as
pedagogical. For example, one student was concerned that, although they felt they had
the correct answer, the bulb on the circuit was not lighting up. A fellow student pointed
out that the current was not great enough to light the bulb. While this issue could be
resolved by placing limitation on the assignment, it did result in reflective and
collaborative learning. Students discussed solutions and demonstrated how excessive
current would result in the bulb “blowing up”.

The use of the virtual labs also had a catalytic impact. Tutors used the virtual labs as a
Teaching tool in order to further develop and enhance instructional materials. For
example, one tutor used screenshots of the Electricity Circuit Builder to illustrate
important concepts. Without this tool the tutor would traditionally resort to drawing these
diagrams by hand. The lab allowed him to develop better quality learning resources much
more quickly for use both in lectures and online.
EVALUATION

Semi-structured interviews were conducted with the three tutors involved. They reported great satisfaction with the virtual labs. They cited, in the case of electricity, the ability to show visually things such as Kirchhoff’s and Ohm’s laws; to “see” flows and meters and to take screenshots. One of the tutors felt making the tools available as an optional resource would not have been as worthwhile as incorporating them into assessments as mandatory exercises. The tutors all enthusiastically engaged with the technology. This is not wholly unsurprising given their engineering and technical backgrounds. While the tutors expressed frustration that two virtual labs were relatively limited in scope, they were interested in using GGFL to discover, evaluate and incorporate new resources.

Previous research of Oscail online resource usage has found that non-mandatory resource usage spikes around notifications about, or discussions of those resources [20]. An analysis of how the labs were used in courses where they were optional and mandatory was made. It revealed that similar proportions of students accessed the resources but where resources were part of mandatory assignments frequency of usage was greater (on average 3.6 times compared to 1.7). Although it would be expected that students access resources more when they can achieve marks it is perhaps surprising that students still make a relative amount of use of optional resources. For instance over a third (9) of the 29 students who accessed the tools in CT1 (n = 43) did so more than once, which is noteworthy for marks-orientated and time-poor distance learners.

An analysis of the exam questions taken by students yielded an interesting finding. In the exam, the average score for the question in the area covered by Electrical Circuit Builder was 60% of the available marks, the same as the overall question average of 60% (21 questions, 28 students). However the number of students who took this question was high at 26 compared to an average question attempt of 18 students and was the second highest scorer for total student marks gained per question.

Students were surveyed about their experience of using the online lab tools through an online questionnaire via Oscail’s custom-developed student feedback tool. Respondents gave the following average likert scores when asked to agree with statements about the labs (1=completely agree and 5 = completely disagree). As mentioned above there are two groups who used the virtual labs, one as an optional resource for self-directed study and the other as part of continuous assessment contributing to their final module mark. There were eight and nine respondents respectively from the groups of 43 and 37 students.

<table>
<thead>
<tr>
<th>Likert Statement</th>
<th>Digital Logic Circuit Builder</th>
<th>Electrical Circuit Builder</th>
<th>As Optional Resource</th>
<th>Part of Continuous Assessment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Easy to use</td>
<td>2</td>
<td>1.8</td>
<td>1.8</td>
<td></td>
</tr>
<tr>
<td>Enhanced my learning</td>
<td>2</td>
<td>1.8</td>
<td>1.3</td>
<td></td>
</tr>
<tr>
<td>Would like more lab work</td>
<td>1.7</td>
<td>1.8</td>
<td>1.2</td>
<td></td>
</tr>
<tr>
<td>Average Times Used</td>
<td>Digital Logic Builder</td>
<td>Electrical Circuit Builder</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>9.5</td>
<td>8.8</td>
<td></td>
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</tr>
</tbody>
</table>

Student comments emphasised the experiential benefits of the virtual labs e.g.

“I thought this was a brilliant tool and really helped me understand logic circuits. I cannot say strongly enough how much this enhanced my learning. Excellent.”

“Very easy to use made things more practical to see something actually in use.”

**CONCLUSION**

Collaboration in online learning has been extensively studied [21, 22] including its use in experiential and particularly experimental contexts, but has remained hitherto costly to implement [23]. Here we describe small scale online virtual labs in conjunction with a virtual learning environment for collaboration through asynchronous online discussions. Oscail has had success utilising online discussion forums for peer assessment and teamwork [24][25]. Building this element formally into online lab work seems feasible and worthwhile and is planned for the future. The use of the virtual labs provided a satisfactory substitute to physical labs within the context chosen and much scope for the collaborative element to be expanded exists. This can be achieved through the careful selection of resources and innovative assignment rather than having to increase the technical sophistication of the environment or invest in a costly and time-consuming development effort. Learning resource repositories such as GGFL, NEEDS (The National Engineering Education Delivery System) and in Ireland the National Digital Learning Repository (NDLR), are gaining increased traction in education [26] [27]. Much research and development has focused on creating learning objects, describing and archiving them and developing models and guidelines for their reuse. The crucial emerging change is that the number of learning objects available from repositories is reaching critical mass. What are now needed are case studies of successful reuse – perhaps the least glamorous part of the process – to test whether development efforts have been worthwhile. Is there an incentive to repurpose and reuse existing technology and press it into educational service in new contexts? There may be trade-offs. A simple generic lab may be easy to embed, pedagogically and technically, into a new learning context. A more complex lab may be more difficult to source and reuse but its greater functionality may make it a more worthwhile educational tool. Not all resources travel well. Another issue is how best to integrate online labs into on-campus teaching. Can they be used to reduce the time spent in physical labs or play a role in safety training? An attempt has been made here to address some issues emerging from the use of online lab tools but there remain many research questions to be answered in this area.

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CONTENT DELIVERY AND CHALLENGES IN EDUCATING HYBRID STUDENTS

David Molloy

School of Electronic Engineering, Dublin City University
E-mail: david.molloy@dcu.ie

ABSTRACT
Traditionally, taught postgraduate programmes placed students in well-defined categories such as ‘distance learning’ and ‘on-campus” or “part-time” and “full-time”. The practical reality is that postgraduate students rarely fall into such simple, diametric roles and can be more suitably generalised under the concept of the “hybrid student”. Hybrid students are dynamic, with changing requirements in relation to their education. They expect flexibility and the ability to make changes relating to module participation level, study mechanism and lecture attendance, in order to suit personal preference and circumstance. This paper briefly introduces the concept of the hybrid student and how the concept has been handled within the School of Electronic Engineering at DCU. Following this, some discussion is provided in relation to a number of the content delivery technologies used in programmes facilitating these students: HTML, PowerPoint, Moodle, DocBook and Wiki. Finally, some of the general challenges, which have been encountered in supporting such diverse students, are briefly discussed.

INTRODUCTION
The RACeE programme at Dublin City University (www.racee.ie) is believed to be one of the first of its kind in Europe to deliver a course for credit entirely via the Internet. Since 1996, the RACeE (Remote Access to Continuing Engineering Education) programme has provided an opportunity for engineers to update their skills remotely [1].

RACeE, in more recent years, has taken the form of a mechanism of study, rather than a programme. It has become a merged and integral part of the Electronic Engineering Masters programmes at DCU. The benefits of this merger have, together with a number of other initiatives and factors, provided considerable growth in student numbers in recent years, as illustrated in Figure 1.

Earlier definitions of student categories have become blurred. Students are no longer considered to fall into the simplistic (and limiting) categories of ‘distance learning’ and “on-campus” or “part-time” and “full-time”. Instead, the single concept of the “hybrid student” is utilised by the School of Electronic Engineering.
Figure 1: Change in number of taught postgraduate students with time. **Note:** The data shown includes all students, for whom education may be spread over multiple years, either by choice or academic performance. Hence, the actual number of new registrations and graduations on a yearly basis would represent a lower figure.

A hybrid student, for example, might wish in a single academic year to:

- Attend four modules in Semester 1 through traditional on-campus means, while searching for employment
- Following employment, attend one module in Semester 2 on-campus through half-day release from work, occasionally participating through online means where work situations dictate
- Attend one module in Semester 2 through distance learning, occasionally attending the lecture on campus where possible

Flexible, modular-based programmes, without hard-enforced “categories”, enable such an approach to postgraduate education. In addition, remote students take great comfort in the knowledge that they are not participating in merely a “distance education course”, but rather in parallel with traditional on-campus students in a “proper course”. This was predicted by Lawhead et al. who stated – “it is necessary to guarantee that degrees earned primarily by distance learning are equivalent to conventional degrees offered by the same institution or the same type of institution”
The concept of “equivalence of product” must be adhered to for hybrid students, who should receive a common course experience regardless of study mechanism.

It is important not to confuse the concept of a “hybrid student” with that of “hybrid courses”. Hybrid courses (also known as mixed mode courses) are courses in which a significant portion of learning activities have been moved online and time traditionally spent in the classroom is reduced but not eliminated [8]. Hybrid students, on the other hand, have neither a requirement to attend the campus at any time (excluding examinations) nor a requirement to participate via distance learning – the mechanism and rate of study are chosen at their own discretion.

The next section will provide some discussion relating to the delivery of engineering course content to hybrid students. Following this, the remainder of the paper will focus on some of the challenges experienced in the delivery of programmes to such a diverse category of student.

COURSE CONTENT DELIVERY
While there is considerable overlap between the education of distance learning and hybrid students there are some additional issues to be considered:

- Physical lectures must be provided for attending hybrid students.
- Quality of online learning resources must be high and must provide independent means of study.
- Non-attending students should be confident that they are not disadvantaged when compared to attending students.
- Equivalent support should be maintained for all students regardless of study mechanism.
- Verbose notes are less suitable for in-lecture presentation material. Similarly, terse PointPoint slides do not make appropriate, exclusive study material for remote students.

There is a considerable range of deployment mechanisms available for course content. Equally, there is also a vast array of learning tools available to lecturers: surveys, quizzes, forums, synchronous chat, multiple choice questions, whiteboards etc. [9]. While pedagogical arguments can be made on behalf of each of these tools, experience has highlighted three primary elements which should exist for an effective hybrid postgraduate programme:

- **High quality detailed notes:** “The key educational concern of any course, whether it is taught in the traditional manner or on a remote access basis, must be the quality of the course material” [1]. This has been confirmed through student feedback and it has been determined that those courses with standalone, detailed notes written in a book format are more effective from the student perspective. Courses consisting of bullet-point notes or pointers to third party books are regarded negatively.

- **Physical lectures:** On-campus lectures should take place in parallel for students who have a preference of attending lectures, either consistently or occasionally.
- **Mailing List Support:** The hybrid model of postgraduate education makes no assumptions relating to the attendance capability or availability of students at particular times. While scheduled online chat sessions might appear to provide more immediate support, it is unlikely that a time can be facilitated to suit the majority of students. A well-supported mailing list makes no assumptions in this regard and while support is not always immediate it can be guaranteed regardless of personal student timetables. In addition, mailing lists provide peer support, resulting in some reduction in teaching overhead.

To focus on the first of these points, we will introduce some of the various mechanisms for the delivery of content, which are in use within the School of Electronic Engineering at Dublin City University.

**MECHANISMS FOR DELIVERY OF CONTENT**

1. **Hypertext Markup Language (HTML)**

   HTML is the predominant markup language for web pages and provides a well structured means of describing text-based information in a document. It is the most widely used and oldest format for the purpose of the online deployment of notes, although frequently as a front-end to application specific formats, such as Word, PDF and PowerPoint. Benefits of using well-written HTML include accessibility, effective presentation and relative portability across mobile devices. One negative aspect is that there is an overhead associated with users either learning HTML or becoming familiar with the use of a graphical HTML editor (WYSIWYG). Additionally, there is a technical overhead with setting up access restrictions and file transfer mechanisms, although the majority of universities would provide such facilities.

2. **Moodle**

   Moodle is a free, software e-learning platform and is designed to help educators create online courses [4]. It is frequently referred to as a Course Management System (CMS), Learning Management System (LMS), or Virtual Learning Environment (VLE) – each of which essentially equates to the same concept.

   Moodle is the e-learning platform of choice within Dublin City University and has demonstrated itself to be both stable and effective. However, in the School of Electronic Engineering there has been a low uptake in using the facility, due to existing previous formats and a lack of intuitiveness associated with Moodle. Benefits in using Moodle include the provision of additional teaching tools which may be used in conjunction with traditional notes.

3. **PowerPoint**

   PowerPoint is widely used by educators in traditional, in-classroom teaching models. While terse, bullet-point slides provide an effective focus for teaching in such models, their use (as a standalone source) proves less effective in supporting distance learning students. This returns to the concept of “equivalence of product” – students who participate on-campus one week and via distance learning the following week, should not notice a significant change in quality in their experience. PowerPoint slides are best used in conjunction with an alternate source of detailed notes and/or video lecture resources. In this way, the benefits of using a persuasive technology such as PowerPoint can be experienced with no learning diminution for particular students.
4. **DocBook**

DocBook is a format of XML used for technical documentation. It enables users to create document content in a presentation-neutral format. DocBook documents do not describe the visual formatting aspect of their contents, but rather the meaning of those contents [5].

Consider a snippet of DocBook:

```xml
<?xml version="1.0" encoding="UTF-8"?>
<book xml:id="simple_book"
 xmlns="http://docbook.org/ns/docbook">
<title>My Book Title</title>
<chapter xml:id="chapter_1">
<title>Chapter 1</title>
<para>This is chapter 1</para>
<para>This chapter is <emphasis>important!</emphasis>!</para>
</chapter>
<chapter xml:id="chapter_2">
<title>Chapter 2</title>
<para>This is another chapter!</para>
</chapter>
</book>
```

Combined with XSL Stylesheets, these documents may be transformed automatically into a number of formats, including HTML and PDF. The above example could be transformed into a multiple page HTML “document” (e.g. 1 page for title/index, 1 page for each chapter). Likewise, using an alternative transformation, it could be rendered to a PDF book.

A number of lecturers have used DocBook to great effectiveness. Using a simple server-side system it is possible for example to secure PDF files against editing, customise notes for individual students, watermark pages and offer a number of printing formats (such as 2 “pages” of notes per A4 page) [11]. This has obvious benefits for lecturers concerned about the intellectual property relating to their notes.

5. **Wiki/Content Management System**

There are a number of utilities available which act as both Wikis and Content Management Systems (CMS). Daisy is a java-based content management system that offers both services. While Daisy can be used for many alternate purposes, it is ideally suited for information-rich, structured content such as course notes [6].

Using a CMS such as Daisy provides a number of advantages, including:
- Generic, accessible HTML notes produced without knowledge of HTML
- Automatic generation of printable PDF documents
- Browser, software, OS and plug-in independent, free editor
- Automatic generation of search facilities within course material
Facility for student contribution, from fixing minor typos and making comments to the production of entire sections of notes
- Easy support for the deployment of multimedia formats such as video and audio
- Support for security access control on notes
- Version control and historical rollback

On the negative side, there is some initial learning in using the Daisy Editor and some technical involvement in setting up the Daisy application on a server.

**DEVELOPMENT CHALLENGES**

There are a number of challenges to be tackled during the deployment of course material for hybrid students. Some of the more important aspects are discussed briefly below.

1. **Intellectual Property**

Most lecturers prefer to keep their course content as restricted as possible, while facilitating appropriate access. Unless access restrictions are put in place, an implied license to make copies of the material is granted, so it is important to control access to intellectual property [1]. This can be achieved using any of the delivery mechanisms discussed (in the case of DocBook/PowerPoint, in conjunction with HTML) by utilising simple username/password access controls.

Issues may also arise on whether or how to protect an author’s investments in course development or materials. It may also be necessary to provide some control over “setting accidental or intentional changes to Web-based materials” [2]. The custom DocBook approach has proven popular with lecturers who were concerned that their course notes might either be modified or reused in other modules/training courses. The facility to watermark PDF notes, protect documents from editing and the ability to place student details in headers or footers provides this extra element of security [11].

2. **Plagiarism**

The predominance of plagiarism in any programme is difficult to quantify. While universities generate policies for handling plagiarism, the detection rate is of most concern. Some observations have been made:

- Facilities such as Turnitin [12] are effective at detecting some elements of plagiarism, but lack the functionality to handle other formats, such as detection of stolen source code. Tools such as Moss and Jplag provide facility for the analysis of source code, although this is a notoriously difficult problem to address. Plagiarism detection software has several drawbacks, so manual checking and human judgment is still needed [7].

- Plagiarism has been more commonly found with students attending the campus, particularly where a “peer group” has formed.

- Plagiarism issues create an effective glass ceiling on the percentage of marks attributable to continuous assessment, particularly in a course with a high quantity of students.
3. Examinations
One of the core restrictions on academic programmes within the school is the requirement to sit examinations at Dublin City University. Arrangements may be made with other institutions in the case where a number of students are taking the modules remotely at the same location. In general, direct supervision is required for academic integrity.

4. Lecture Timetabling
A number of steps have been made to ensure suitability for hybrid students in relation to timetabling. Unlike many part-time programmes, lectures do not take place in the evenings or at weekends. They are scheduled in exclusive three-hour blocks either from 10am-1pm or 2pm-5pm. In addition, students have considerable flexibility in the set of modules that are chosen. In the case of the most flexible programme, a student may choose any eight of a total of twenty two different modules. Combined, with the capability to take any of these modules remotely, this provides a range of customization options for almost all traditional categories of students. The natural exception is the part-time student who wishes to attend campus for evening/weekend study. Feedback indicates that this is an almost inexistent category of student, the majority of similar students citing preference for online study.

5. Video Enhancement
Numerous attempts had been made to perform “traditional” video recording of lectures since the development of the programmes. These had mostly been found ineffective due to the high manpower requirements involved, both at the recording and editing phase. In recent years, Camtasia has been deployed to strong success and positive student feedback. Camtasia is a professional solution for recording, editing and sharing high quality screen video on the web [10]. In essence, it will perform a video screen capture of a computer screen and record the lecturer’s voice during lectures. While it is effective in recording computer demonstrations and PowerPoint presentations, it is less suitable for “chalk and talk” sessions. Additional support for such functionality can be achieved using tablet PCs/graphic tablets. Wireless microphones, such as the Plantronics CS60 provide roaming functionality for more mobile lecturers.

6. International Visa Requirements
Citizens of certain countries, who wish to pursue education in Irish Universities, must meet a number of visa requirements set by the Irish Naturalisation and Immigration Service. Among these is the requirement that the student has “been accepted and enrolled on a course of full-time education, involving a minimum of 15 hours organised daytime tuition each week” [3]. One of the limitations of the hybrid student model is that certain nationalities of students may have enforced minimum levels of study. In addition, careful analysis of academic performance must be made in relation to those students who are deemed to be lacking in annual progression.

DISCUSSION
Both programme structure and content design require considerable forethought in relation to handling the different subcategories of student. The structure utilised within the School of Electronic Engineering at DCU starts from the basis of assuming that all students are simply “hybrid”.
Many of the requirements for supporting hybrid students are identical to those for supporting distance learning students. The primary difference is that physical lectures must take place in parallel. This introduces some new considerations relating to the format and deployment of course material. Lecturers must create courses with one primary question in mind – “Am I developing a course which is effective and fair to all of my students, regardless of their mode of study?”

Issues such as intellectual property, plagiarism and examination location provide similar challenges for both hybrid and distance learning students. However, some additional considerations must be made for hybrid students in relation to on-campus timetabling and visa requirements.

In relation to the provision of video for remote students, teaching with a hybrid student model provides a considerable benefit. When combined with suitable screen/voice capture software, remote students experience a feeling of participation in a real class environment and a strong sense of equivalence of product.

REFERENCES
ENHANCING THE LEARNING ENVIRONMENT USING CLASSROOM RESPONSE SYSTEMS

Eilish McLoughlin

CASTeL, School of Physical Sciences, Dublin City University
E-mail: eilish.mcloughlin@dcu.ie

ABSTRACT

Classroom response systems (CRS) offer a management tool for engaging students in the classroom. These systems have been used in a variety of fields and at all levels of education. Typical goals of CRS questions are discussed, as well as the advantages to both students and instructors as a result of using them. These systems are especially valuable as a means of introducing and monitoring peer learning methods in the large lecture classroom. But the efficacy of using these systems depends strongly on the quality of the questions used. The integration of a CRS in an introductory physics module is discussed along with examples of questions used and the student assessment carried out.

INTRODUCTION

The simplest classroom response system (CRS), commonly called clickers, look like a basic TV remote control and work using infrared or radio frequency technology to transmit and record student’s responses to questions. A small receiver is connected to a personal computer and placed at the front of the class. Each CRS is registered to a student, or can be set as anonymous if preferred, and each unit generates its own identifiable signal. The system allows for active participation by all students and provides immediate feedback to the instructor, and the students if desired, about the understanding/misunderstanding of the material being presented.

Traditional instruction presumes two types of ‘knowledge’: Facts and ideas which are things that can be packaged into words and Know-how which can be packaged into words as rules or procedures. These ‘packages of knowledge’ are then ‘told’ to the students, but students usually miss the point of what we tell them, if they listen at all and key words or concepts do not elicit the same connections for students as they do for the instructor. CRS have been used in higher education since 1998 as a mechanism to increase student interaction and transform student learning, particularly in the challenging large lecture environment [1,2]. By engaging their minds in class students become active participants in the learning process. By providing frequent feedback to students about the limitations of their knowledge, CRS-based instruction helps them to take charge of their own learning, seeking out the information and experiences they need to progress. By providing feedback to an instructor about student’s background knowledge and preconceptions, CRS-based pedagogy can help the instructor design learning experiences appropriate to the students’ state of knowledge and explicitly confront and resolve misconceptions. Many studies have reported positively on student satisfaction with classroom response systems, on whether it made their class more interesting, improved attendance, etc., [3-5]. Other studies have reported on learning outcome related to the use of interactive engagement pedagogical methods in large science courses [6].
A controlled study by Ebert-May et al. shows that student confidence in their knowledge of course materials is significantly increased in courses taught using interactive engagement methods over those taught by traditional lecture: “Results from the experimental lectures at NAU suggest that students who experienced the active-learning lecture format had significantly higher self-efficacy and process skills than students in the traditional course” [7]. A comparison of mean scores from the self-efficacy instrument indicated that student confidence in doing science, in analyzing data, and in explaining biology to other students was higher in the experimental lectures (N = 283, DF = 3, 274, P < 0.05). A large study by Hake [8] of 63 introductory physics courses taught with traditional methods versus interactive engagement (IE) methods, examined student learning outcomes using a commonly applied pre- and post-test design based on the Halloun-Hestenes Mechanics Diagnostic test and Force Concept Inventory. The study, which included 6,542 students, concluded that "A plot of average course scores on the Hestenes/Wells problem-solving Mechanics Baseline test versus those on the conceptual Force Concept Inventory show a strong positive correlation with coefficient r = + 0.91. Comparison of IE and traditional courses implies that IE methods enhance problem-solving ability. The conceptual and problem-solving test results strongly suggest that the use of IE strategies can increase mechanics-course effectiveness well beyond that obtained with traditional methods [original emphasis]." A recent study by Kennedy and Cutts [9] examined actual response data per student over the course of a single semester. In-class questions were of two types, one which asked the student to self-assess their study habits, and the other which focused on course content. These data were analyzed with end-of-semester and end-of-year exam performance results. Their investigation showed that students who more frequently participated in use of the personal response system and who were frequently correct in their responses, performed better on formal assessments. Students who infrequently responded, but did so correctly, nevertheless performed poorly on formal assessments, suggesting level of involvement during the class is positively correlated with better learning outcomes. These studies suggest that better learning outcomes are really the result of changes in pedagogical focus, from passive to active learning, and not the specific technology or technique used. Without a focused, well-planned transformation of the large lecture format and pedagogical goals, the technology provides no advantage. If the manner in which the technology is implemented in class is neither meaningful nor interesting to the student, then participation lapses. Ultimately, what these studies demonstrate is that student participation is key to positive learning outcomes.

The benefits of teaching by questioning are now widely recognized and the technique is becoming widely used. A recent Harvard survey indicated over 700 instructors use the technique, with about 400 using a variation called Peer Instruction. Peer Instruction (PI) is a student-centered instructional approach developed at Harvard by Eric Mazur [10-12]. This method has been welcomed by the science community and adopted by a large number of colleges and universities due, among other reasons, to its common sense approach and its documented effectiveness. The reasons for posing questions in class include: To assess background knowledge; To test if what has been taught has been understood; To provoke a class discussion; To emphasize or reinforce a point; To introduce a new topic; To see if students can combine past material to reach an understanding of present material; To see if students have read the textbook; To see if they understood what was done in the lab; To test student's physical intuition before a demonstration or before teaching a subject; After a demonstration to evaluate student's interpretation of what happened and to correct a misconception or to lead students to a better understanding.
The efficacy of CRS depends strongly on the quality of the questions used. Creating effective questions is difficult, and differs from creating exam and homework problems. Every CRS question should have an explicit pedagogic purpose consisting of a content goal, a process goal, and a metacognitive goal. Questions can be engineered to fulfill their purpose through four complementary mechanisms: directing students’ attention, stimulating specific cognitive processes, communicating information to instructor and students via CRS-tabulated answer counts, and facilitating the articulation and confrontation of ideas [13]. Several literature reviews have recently been published on the use of CRS in the classroom and provide an overview of current research and best-practice tips [14-18].

RESOURCES AND METHODS

The CRSs used in this study are the Quizdom Q4 (http://www.qwizdom.co.uk/) used in conjunction with Microsoft PowerPoint. There are several forms of questioning available on these units, i.e. multiple choice-Conceptual or Numeric, True/False, Yes/No, Rating Scale, Sequencing questions and numerical input. A schematic of the Quizdom Q4 classroom response system is presented in Figure 1. During lectures, there are six basic steps that an instructor follows when using a CRS:

1. The instructor presents a question, problem or information.
2. The instructor sends a question
3. The students think about and/or discuss the question and respond
4. The instructor displays the responses
5. The instructor analyses the results
6. The instructor provides feedback to the students and uses information for tests and grading.

Figure 1. Schematic of Quizdom classroom response system.

The module chosen to pilot the use of a CRS system is an introductory physics module on waves and optics delivered to 22 first year University physics students. This module consists of 24 lectures and 12 tutorial sessions, with a 20% weighting on continuous assessment (CA) and 80% weighting
on the end of module examination. During the module, CA was carried out on four separate occasions, in the form of a test consisting of 20 Multiple Choice Questions (MCQ), with the CRSs used twice and two paper-based tests. A range of question types were posed in both CA and in final examination questions, including: recall, calculation, interpretation, reasoning and application.

Example 1: A mass on a spring undergoes SHM. When the mass passes through the equilibrium position, its instantaneous velocity is: A) is maximum. B) is less than maximum, but not zero. C) is zero. D) cannot be determined from the information given.

Example 2: You drop a stone into a deep well and hear the splash 2.5 s later. How deep is the well? A) 25 m, B) 27 m, C) 29 m, D) 31 m.

Example 3: The figure is a "snapshot" of a wave at a given time. The frequency of the wave is 120 Hz. What is the wavelength in metres?

RESULTS

Figure 3 presents an overview of the individual performances in all aspects of assessment, CRS-based MCQ assessment, paper-based MCQ test and the final end of module examination.

Figure 2. "snapshot" of a wave at a given time.

Figure 3. Students’ performance in Continuous Assessment (CRS and Test) and Final Exam.
The results show that only 68% of the students participated in the CRS assessment, and the average difference in grades between exam-CRS was 3%, exam-test was 6% and test-CRS was 7%. These results do not show any statistical significance of the effect of the form of assessment on the student’s performance. Unsurprisingly, the top 60% of students were consistently those that attended lectures and tutorials and actively participated in class. When students were asked about the use of CRS in their module:
- 95% of the students agreed that the CRS were easy to use
- 85% agreed that the questions required a deep understanding of lecture material
- 96% agreed that the questions were directly related to material covered in lectures
- 80% agreed that the CA element was an advantage to their learning
- 78% agreed that they liked questions where they could demonstrate that they understood core concepts
- 92% agreed that the CRS should be continued in the same module next year.

DISCUSSION AND CONCLUSIONS
The benefits of using CRS in Higher Education have been well documented and the integration of these systems across all disciplines has been successfully implemented for a variety of uses [19]:
- Assessment - as a substitute for a paper test.
- Instant feedback on learning - with this, the lecturer can discover which points have already been understood by the students and which may need some further clarification.
- Instant feedback to the lecturer on their teaching - particularly lecturers could ask what the best and worst aspects of his/her teaching were, and attempt to correct them immediately.
- Peer assessment - students who are giving presentations could be graded instantly by their peers on the quality of their work.
- Community building - general questions, for example why students chose this particular class, would create a sense of mutual awareness within the group.
- Demonstrating human response experiments - when illustrating conformity, for example, the responses to early questions could be faked in order to see whether the class would change their answers later.
- Encouraging debate - students who have had to commit privately to a definite opinion are much more likely to feel the need to justify their answer in peer

In this pilot study, the CRS was used with a small cohort of students which a view to gaining experience in the technology and determining if this form of evaluation provided a appropriate measure of student engagement and performance. As discussed above, there is no indication that the evaluation of student’s performance is enhanced or diminished by this format of questioning and certainly this type of system benefits an instructor in terms of being a convenient way of determining knowledge of the lecture content at any time, being easy to use and take up little time from the lecture. However, the design and development of suitable questions remain key to its effective implementation.
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NATIONAL INSTRUMENTS PRODUCTS FOR TEACHING AND LEARNING

Adam Bakehouse
Academic Field Engineer, National Instruments
E-mail: adam.bakehouse@ni.com

ABSTRACT
A range of teaching software and hardware teaching and learning resources are provided by National Instruments specifically for the academic community. The products cross the range from primary school, secondary level, and third level through to postgraduate level. In particular at higher level, free and purchasable courseware is provided for the teaching of mechanics, bioengineering, instrumentation, mechatronics, digital processing, digital electronics, microelectronics, and design amongst many other areas. This course content is largely produced by academics for academics using platforms such as Labview software and NI ELVIS which is a mini-microelectronic laboratory which is now in standard use by many of the top internationally ranked Universities. The learning of programming is also supported though Labview with course content provided and allowing all the standard programming concepts such as for loops, while loops, iteration counting, pointers, and array manipulations to be easily learnt. An overview of these and other resources that are currently available will be provided in this presentation.
DEVELOPMENT OF THE NEW MECHANICAL ENGINEERING COMMUNITY OF PRACTICE WEBSITE

Heather James
Department of Engineering, IT Sligo
E-mail: hjames@gmail.com

ABSTRACT
The Mechanical Engineering Community of Practice supports innovation and enhancement of the teaching and learning activities within engineering disciplines at third level in Ireland. The website will be one of the means through which this goal can be achieved. The site will highlight good practice, and promote the work of the members, and facilitate sharing and communication. As well, the site offers more collaborative functions for those members who may which to make contributions and contact colleagues through the site. This presentation will demonstrate existing functionality and planned features. Feedback from members for changes has always been welcomed and this will be used to direct future development within the coming months.

Figure 1: Screenshot of home screen for mechanical engineering community of practice web-site which is under construction.

REFERENCE
Future of Engineering Education
TEACHING TO ASSIST STUDENTS FULFIL LEARNING OUTCOMES: AN ENGINEERING PERSPECTIVE

Edmond Byrne

Department of Process and Chemical Engineering, University College Cork, Ireland
E-mail: e.byrne@ucc.ie

ABSTRACT
Engineering educators are quite familiar with a learning outcomes based approach to module and programme delivery. This approach was pioneered in the United States through ABET towards the end of the last century and is now a common requirement among engineering programme accreditation institutions. Learning outcomes reflect an end point in a learning process. However these are not always achieved, even when students succeed in passing a given module. Other elements in this learning process include student learning and the approach taken, student perception of the learning task in hand and previous learning experiences. Many of these elements in turn can be influenced by the lecturer through their own teaching style, assessment, module workload and assessment feedback. Essentially good teaching, in the broadest sense, can help promote good learning and this can ensure that the signalled learning outcomes are achieved. When this happens there is a mutual sense of motivation and satisfaction for learner and teacher alike. This paper reflects on a teaching-learning model that takes into account the aforementioned elements and relates it to engineering educational practice and to the author’s own experience of teaching and learning.

REFERENCES
THE HIGHER EDUCATION ACADEMY ENGINEERING
SUBJECT CENTRE - SUPPORTING ENGINEERING
LEARNING AND TEACHING IN THE UK

Liz Willis
The Higher Education Academy Engineering Subject Centre, UK
Email: liz@engsc.ac.uk

ABSTRACT
This paper considers why there has been an increased interest recently in recognising and rewarding excellence in teaching and learning in higher education in the UK, and provides information on the support available for learning and teaching. It aims to provide an overview of the work of the Higher Education Academy and the discipline specific support offered by the Engineering Subject Centre. The paper offers an introduction to a number of the Centre’s activities including networking and knowledge brokerage, support for pedagogic research and the assessment of learning outcomes.

INTRODUCTION
Over the last decade a number of initiatives have been introduced in the UK with the aim of providing support for learning and teaching in higher education and more recently improving the status of teaching. January 2000 for example saw the launch of the UK-wide Learning and Teaching Support Network (LTSN), comprising 24 subject centres and a Generic Centre. The Network was established following a review of existing learning and teaching initiatives which acknowledged “that its subject orientation is the source of its strength and success”. [1].

The Higher Education Academy was formed in May 2004 from a merger of the Institute for Learning and Teaching in Higher Education (ILTHE), the Learning and Teaching Support Network (LTSN) and the TQEF National Co-ordination Team (NCT) [2, 3]. The Academy’s mission is to help institutions, discipline groups and all staff across the UK to provide the best possible learning experience for their students and it receives a grant from the four UK funding bodies along with institutional subscriptions. The Engineering Subject Centre is one of 24 Subject Centres which make up the subject network of the Higher Education Academy. The Engineering Subject Centre, which is based in the Faculty of Engineering at Loughborough University, draws upon the expertise of engineering academics and educationalists from across the higher education sector, and works closely with the leading engineering professional bodies. As the national centre for all engineering academics in the UK, the Engineering Subject Centre delivers subject-based support to promote quality learning and teaching. It achieves this by stimulating the sharing of good practice and innovation, thereby helping engineering academics to contribute to the best possible learning experience for their students. The Centre employs 12 staff (8 FTE), complemented by 9 Associates across the UK.
The Engineering Subject Centre's Strategic Aims are:

- To provide high quality information, advice and support on curriculum development, learning, teaching and student assessment.
- To establish and maintain links with all the Centre's stakeholders in order to maximise the opportunities for the sharing of knowledge on learning and teaching innovations, and to advise and broker on subject based policies.
- To promote awareness of good practice and innovation in learning and teaching in engineering.
- To encourage the development, implementation and recognition of good practice and innovation in learning and teaching in engineering.
- To provide discipline based opportunities for professional development of staff in Higher Education.
- To play a leading role in the development of research in engineering pedagogy.
- To be a responsive, efficient and accountable organisation.

In January 2005 the Higher Education Funding Council for England (HEFCE) announced the funding of 74 Centres for Excellence in Teaching and Learning (CETLs) with the intention that "funds received by CETLs will be used to recognise and reward excellent teachers and enable institutions to invest in staff, buildings and equipment to support and enhance successful learning in new and challenging ways" [4]. This initiative represents HEFCE's largest ever single funding initiative in teaching and learning. The Subject Centre now works with a number of those CETLs, which have relevance to the engineering community in order to share expertise and innovation within their host institutions and across the UK.

THE ENGINEERING SUBJECT CENTRE – WHAT DO WE OFFER ENGINEERING ACADEMICS?

Our purpose is to provide subject-based support to enhance learning and teaching in engineering education. We achieve this through the engagement of and interaction with UK engineering academics and the wider engineering community including professional bodies, other networks and funded engineering education projects. The key contacts in the majority of all engineering departments who deliver HE engineering programmes across the UK have been identified.

The Engineering Subject Centre has a comprehensive website which aims to be the gateway to the news, events, and resources that are current in engineering education. Receiving an average of 10,000 hits a month, the site is kept up to date with the addition of resources and information on topical issues on engineering education. We communicate regularly to the community through our electronic mailing list and our newsletter, translate. The Centre posts a fortnightly e-bulletin to engineering@jiscmail.ac.uk passing on information about activities and resources relevant to learning and teaching in engineering, consulting the community about engineering education issues and providing an opportunity for people to ask for advice and for the community to respond. Translate is published 3 times a year and contains progress reports from the Centre and nationally funded projects, news, diary dates and featured articles.

All of the resources which we have commissioned and published are available to download on our website. Topics on which we have resources available include assessment, employer engagement, ethics, and learning and teaching theory. Our Resource Database offers a one
The Engineering Subject Centre offers funding opportunities for Mini-Projects (up to £3500) and Special Interest Groups (up to £1500) to enable the development and sharing of good practice in engineering education. The Centre has funded over 40 projects to date, allowing staff in departments to engage in small scale research and development projects.

The Centre also offers a programme of professional development workshops and national events including workshops for programme leaders and new lecturers, pedagogic research support and events on current issues in engineering education. We have also hosted a number of conferences including EE2008 - the international conference on innovation, good practice and research in engineering education.

THE ENGINEERING SUBJECT CENTRE TEACHING AWARDS
The Engineering Subject Centre’s Teaching Awards were introduced in 2004 to provide an opportunity for engineering academics to receive national recognition for the high quality of their learning and teaching practices. Nominations and applications are taken from engineering academics at any UK University. The first stage of the selection process is for these applications to be reduced to a shortlist of six who will then work over the coming academic year with a member of the Engineering Subject Centre in order to develop a case study. The case study is developed from data gathered through a demonstration of the teaching and learning, the materials available, interviews with the tutor and student feedback gathered by means of questionnaires and a focus group. An overall winner of the award is then selected from these completed case studies and presentations made at an appropriate conference.

SUPPORTING PEDAGOGIC RESEARCH
Loughborough University is fortunate to host both the Higher Education Academy Engineering Subject Centre and the engineering focused Centre for Excellence in Teaching and Learning (engCETL). Building on the Subject Center’s aim to play a leading role in the development of research in engineering pedagogy and the engCETL aim to achieve “a cultural change that supports a reflective and evidence-based approach to teaching”, staff at the two centres collaborated to provide a pedagogic research workshop for engineering academics [5]. The workshops aim to increase pedagogic understanding and equip engineering academics with tools to enable them to reflect on and research their own practice and the impact this has on student learning. We want academics to understand what is meant by pedagogy and to engage with pedagogic research literature and the scholarship of teaching and learning [6].

The workshops take advantage of complementary staff expertise within the two centres to allow us to work across both of the disciplines involved (pedagogy and engineering) and to have the necessary conversations in order to ‘break down the jargon’. One member of staff has experience in facilitating workshops for engineering academics and moderating bids for research and evaluation mini projects while the other works in the field of pedagogic research and evaluation. Previous studies have shown that “a collaborative approach, involving subject specialists and educational researchers, provides a robust model for raising pedagogic research capacity” [7, 8].
The workshops and resources, in addition to encouraging engineering academics to engage with and carry out pedagogic research also provides a support mechanism for engineering academics wanting to publish in the Subject Centre’s Journal.

*Engineering Education: Journal of the Higher Education Academy Engineering Subject Centre* is a peer-reviewed, international journal. The journal is published twice a year and aims to promote, enhance and disseminate research, good practice and innovation in all aspects of engineering education. The journal publishes a range of original articles on engineering education at the higher education level.

The journal is published in two media: traditional printed form and a web-based e-journal. The printed version of the journal is distributed freely to every engineering department in the UK and UK university libraries, and the e-journal is available freely online - thus providing a publication that is readily accessible to all engineering academics throughout the UK.

**THE ASSESSMENT OF LEARNING OUTCOMES – SUPPORTING CHANGE**

Through its close involvement with UK based networks and organisations the Centre has been able to offer support in wider curriculum issues such as accreditation of degree programmes, enhancement of the student learning experience and providing representation for the engineering academic community. Collaboration has included working with the Engineering Council UK (ECUK)\(^1\) on the radical review of the standards for registration of Engineers and technicians with the Engineering Subject Centre gathering and collating the academic input to the consultation and facilitating dialogue with the Quality Assurance Agency (QAA)\(^2\), on the revision of the subject benchmark statement for engineering to reflect the changes made [9, 10].

The new UK SPEC for the accreditation of higher education programmes was published in May 2004 and following its publication the Engineering Subject Centre, Engineering Professors’ Council (EPC)\(^3\) and ECUK approached the QAA to open a dialogue regarding the alignment of the UK SPEC and the QAA Engineering Benchmark Statement [11, 12]. On publication of a revised benchmark statement in 2006 the QAA noted that “the approach to the revision of the subject benchmark statement has acknowledged and recognised the evolutionary nature of the output standards for engineering”.

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\(^1\) The Engineering Council UK (ECUK) is a chartered educational charity responsible for setting and maintaining realistic and internationally recognised standards of professional competence and ethics for engineers and higher education programmes can apply for accreditation from the Qualifications Department of one of the professional body members. ECUK's mission is to set and maintain realistic and internationally recognised standards of professional competence and ethics for engineers, technologists and technicians, and to license competent institutions to promote and uphold the standards.

\(^2\) The Quality Assurance Agency for Higher Education (QAA) was established in 1997 to provide an integrated quality assurance service for UK higher education. The QAA is an independent body funded by subscriptions from universities and colleges of higher education and through contracts with the UK higher education funding bodies.

\(^3\) The EPC aims to support, advise and represent the university engineering academic Community, providing an acknowledged forum for senior academics responsible for the provision of engineering higher education and the conduct of research in engineering in UK universities. It promotes all aspects of engineering education and research in universities and encourages interaction with engineering practice.
The introduction of the UK-SPEC and accreditation of engineering degree programmes based on output standards has raised several issues, in particular how to identify evidence that learning outcomes are being met and at what level. Concerns were raised over the competence of academic departments and accreditation panels to competently judge the attainment of learning outcomes.

In May 2005 the Engineering Subject Centre, the EPC and ECUK met to establish how those present could further support the engineering community in working with the assessment of learning outcomes and it was agreed that a working group would be established to support the engineering community. The Assessment of Learning Outcomes in Engineering (ALOE) Working Group aims to provide support to the engineering community to enhance the process of assessing learning outcomes through facilitating the sharing of experiences between programme leaders and accreditation teams and capture and disseminate examples of good assessment practice and how UK-SPEC is informing curriculum design [13].

A series of workshops has already been delivered to programme leaders and members of accreditation teams and a call for case studies aims to capture good practice in the assessment of individuals in groups, assessing creativity in design and the assessment of sustainable design. The group continues to support changes and practices in curriculum design and the assessment of learning outcomes and will showcase the developments in the UK through the ALOE International Conference in November 2008.

EMPLOYER ENGAGEMENT
The Centre also works with key government agendas and one recent example is employer engagement. HEFCE, in responding to the ‘employer engagement’ agenda have made funding available to the Higher Education Academy to pump-prime a number of development projects involving the Subject Centres and relevant Sector Skills Councils. The Engineering Subject Centre received funding to support the ENGAGE project which facilitates dialogue between employers and academics and other key partner organisations who are stakeholders in the employability of engineering, physical sciences and materials graduates. Four working groups were formed to take forward discussions on 4 key areas:

- Work-based learning.
- Levers and enablers (including funding and accreditation).
- Staff development/management of change.
- Building partnerships.

In January, 2008 the project hosted the Engage conference attracting around 100 engineering academics and industry representatives [14].

CONCLUSIONS
The Engineering Subject Centre has a well-established network which represents the key stakeholders in engineering education and with the dedicated funding for a national centre allows us to be successful in engaging with emerging key themes in a proactive way. The Centre offers a range of support activities for Engineering Academics across the UK, engagement in which ranges from individual interest (being members of our mailing list or applying for a teaching award) to whole faculty team interest with the Centre being invited to contribute to learning and teaching days. Our range of communication channels including the
website, newsletters, face to face meetings and workshops facilitates dissemination and knowledge brokerage both throughout the UK and to an international audience.

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RETAINING FIRST YEAR ENGINEERING UNDERGRADUATE STUDENTS

Elaine Smith¹ and Barry Beggs²

Learning Environment Development Centre, Glasgow Caledonian University
School of Engineering and Computing, Glasgow Caledonian University
E-mail: e.smith@gcal.ac.uk

ABSTRACT
The presentation reports on the outcome of five years of experience designing, implementing and evaluating an integrated first year engineering student experience that has resulted in dramatic and sustained improvements in student retention.

Included is an honest exposé of the problems, the effort involved and also the efficiencies gained, short cuts and software tools that have been used. Examples of some of the more successful innovative activities and ideas are given. One example is the 'take your tutor to breakfast' initiative that is fully explained and evaluated.

Over the years of development of this, still evolving, student experience, the issues of student and staff engagement have been addressed in an attempt to provide a caring, controlled and consistent environment for students - the 'Triple C' Model.

Efficiency for staff along with the maintenance of academic standards in accredited degrees has been an essential factor. Risk assessment and diagnostics have been combined with ongoing evaluation of the student experience as the semester continues by using 'minute papers' and other brief evaluation methods. Personal absence management and PDP verification have been integrated into this holistic approach with feedback constantly being provided to students. In this way a partnership has been cultivated between engineering students and academics.

This work described comes straight from classrooms where widening access, engineering student recruitment problems and student retention issues present major challenges. It provides a pragmatic approach with real evaluation along with actual evidence and includes a monthly calendar of suggestions for what first year tutors should be doing as the academic year progresses.
PREPARATION & ACCREDITATION OF LEVEL 7 ENGINEERING PROGRAMMES

Mark McGrath

School of Manufacturing & Design Engineering, Dublin Institute of Technology
Email: mark.mcgrath@dit.ie

ABSTRACT
Accreditation of 3rd level educational programmes by a suitably recognised professional body is of particular relevance in relation to engineering. The completion of a sequence of modules which leads to the attainment of this professionally recognised award is viewed as integral to the undertaking. The engineering technology fields are developing and expanding rapidly and the third level sector must keep abreast of these changes. This is essential if the third level institutions wish to continue delivering programmes which produce graduates who can successfully complete the transition from 3rd level to the various engineering sectors. This paper outlines various aspects of the preparation for, and the facilitation of, the accreditation of a Level 7 Bachelor of Engineering Technology programme in DIT by Engineers Ireland (EI). The generation and presentation of modules which satisfy the programme outcome approach to engineering programme development is overviewed. The accreditation process can be simplified if various steps are taken to ensure that all relevant material is presented to the panel in a logical/coherent fashion. Various personal recommendations are discussed in relation to the layout/structure of supporting documentation as well as presentation of evidence during the accreditation visit.

INTRODUCTION
The Bologna declaration was an agreement which focused on 3rd level education across the EU with a view to establishing convergence on the commonality of approaches to programme delivery [1]. The principle benefit of this increased compatibility and comparability would be the ease with which students could access a vast range of programmes across Europe. The success of this increased student mobility hinges on the commonality of standards and approaches being adopted in the 3rd level institutions in the participating nations. The Institutes of Technology in Ireland responded to Bologna by examining existing programmes with a view to facilitating the adoption of this common strategy to engineering education in Europe. It was proposed that existing three year diploma programmes, which included a two year certificate award followed by a further year to diploma level, would be brought in line with that being employed across Europe. Internal audits of these programmes were carried out within the institutes with a view to moving towards a three year Level 7 ‘Ordinary’ degree. The term ‘Ordinary’ is used here only to signify that these are not at honours degree level. These programmes would produce graduates who could perform at a level intermediate of that of a technician and a professional engineer, namely a ‘Technologist’. DIT introduced the title ‘Bachelor of Engineering Technology’ to be allocated to these degrees which ensured sufficient distinction between the original diploma award and the awards made at honours degree level.
Accreditation of these programmes, a process which ensures consistency of standards in programme delivery and therefore, graduates, is carried out on a five yearly basis by a recognised professional body within the sector. In Ireland this endeavour is undertaken by Engineers Ireland (EI). This accreditation is highly significant if consistent delivery of high quality relevant education in this country is to be continued. The Dublin Institute of Technology (DIT) had a number of Level 7 programmes accredited by EI in February 2008. The Faculty of Engineering within DIT works to a semesterised calendar, each stage of the programme consisting of two semesters each of which consists of 15 weeks. Each stage of the programme constitutes 60 ECTS credits. All modules within all programmes have a 5 ECTS credit rating or a multiple of this. 5 ECTS credits constitute 100 hours of student/learner effort. This is an important consideration during the module development stage. The author of this paper was highly involved in the preparation of one of these programmes and the paper outlines some personal observations/opinion on undertakings which can enhance and streamline this task.

This paper details some aspects of the accreditation process as well as including some personal insights on how best to succeed in the undertaking. Developing modules using the programme outcome approach, preparation of the documentation for the accreditation, and facilitating the actual accreditation panel visit are included. The paper itself is laid out as follows; general introduction to the accreditation of level 7 programmes in Ireland, module development and module descriptors, documentation for accreditation, the accreditation visit, and finishes with some overall conclusions to the work.

ACCREDITATION OF LEVEL 7 ENGINEERING PROGRAMMES IN IRELAND

Programmes which are deemed to be at the appropriate standard for award at Level 7 are considered eligible for accreditation to ‘Associate Engineer’ level. Engineers Ireland defines an Associate Engineer as follows [2]; ‘The Associate Engineer is competent to apply in a responsible manner current engineering technologies in a chosen field. He/she exercises independent technical judgement and works with significant autonomy within his/her allocated responsibility. The performance of his/her engineering technology work requires an understanding of relevant financial, commercial, statutory, safety, management, social and environmental considerations’. EI specify programme outcomes which provide the framework within which the third level institutions may build their engineering programmes. These outcomes, coupled with relevant programme area descriptors, lay the foundations on which to build programmes which may ultimately result in successful accreditation. This ensures that the accredited programmes are of the required high level and that ultimately, and most importantly, graduates are being produced that can perform at Associate Engineer level. The programme outcomes hold the key to successful accreditation. It is essential that the programme team can clearly show that graduates of the programme have the abilities prescribed in the EI programme outcomes. The accreditation process, which includes preparation of documentation followed by a visit by a panel which consists of independent academic and industrial personnel, is as specified by EI [2]. The panel visit ends with the production of a report which outlines detail in relation to the programmes performance under a range of headings as outlined in [2]. It is the responsibility of the participating 3rd level institute to provide the accreditation panel with sufficient information in relation to each of the requirements. Various conditions and/or recommendations can be associated with the decisions made by the panel on completion of the accreditation visit ranging from non-accreditation up to accreditation without any conditions for 5 years. A large
proportion of the panel’s time during the visit is spent on ‘analysis and implementation of programme outcomes’. This aspect of the accreditation process is the major focus of the following sections of this paper. Suggestions which may prove beneficial to those involved in imminent accreditations are included.

MODULE DEVELOPMENT AND MODULE DESCRIPTORS

The programme outcome approach to the development of third level engineering programmes is a significant shift from earlier approaches. Ideally a top-down approach should be taken in the development of the engineering programme [3]. The first question the programme team should ask themselves on commencement of the programme development process should be; “What should a graduate of the programme (or proposed programme) be capable of?” The answer to this question is extremely important as it essentially defines the role of prospective graduates in the workplace. This coupled with the EI programme outcomes should lead to the generation of a listing of ‘programme specific outcomes’ which are particular to the programme in question.

This should then continue towards the following question; “What modules (suite of modules) are required to ensure adequate learning can be facilitated in the proposed areas/disciplines whilst ensuring that the programme outcomes are being met?” Once provisional titles of modules have been decided upon by the programme team work can begin on the development of the module descriptor. Each module author, in consultation with the programme committee, develops a concise module description. These should overview the module and illustrate clear evidence of conformity to the EI programme outcomes. This module description should be specific to the programme in question and in most cases should not be a generic ‘one-for-all’ solution. One methodology which can aid in the development of a module which fulfils all requirements is to ‘justify the inclusion’ of the module throughout development. This essentially means that the author is continuously weighing up the merits of their module against the specifications as laid out by EI and the programme committee/team. This methodology can be adopted at the descriptor stage where the author can discuss the module under the following headings; Knowledge: Breadth & Kind, Know-How & Skill: Range & Selectivity, Competence: Context, Role, Learning-to-learn, & Insight. This discussion forces the module author to identify how their module will contribute to the education of the learner and as such must show how the module performs against the EI programme outcomes. This is a very useful exercise and greatly simplifies the accreditation process as the module author is immersed with the expectations of the module and hence the programme. A short description of the aim of the module is then outlined. This should bring together the description of the module, the skills developed and how the learner/graduate benefits from participating in/completing it.

The required ‘learning outcomes’ should then be produced. This should be a list of measurable expectations derived from the learner’s involvement in the module. Ideally these outcomes should be generated in advance of the syllabus so that due reference is afforded to the EI programme outcomes as well as the specifics developed by the programme committee. Ensuring that these outcomes are measurable is of primary importance and authors should avoid the trap of using words such as understanding, comprehension and appreciation. The number of learning outcomes included in the module descriptor is also significant. Including a large number of learning outcomes restricts flexibility in the module content/delivery. This can result in the lecturer being tied down to very specific material outlined in the learning outcomes, limiting the possibilities of delivering the module to a number of differing class groups simultaneously.
However, having too few learning outcomes can give too much freedom and allow too much room for interpretation of required/desired content. The descriptor is then of less benefit to the learner as it does not give them an appreciation for the expectations from the module. Allowing the programme specific learning outcomes and the description of the module requirements to filter down through a list which consists of measurable verbs is the key to success in this task. The module author should also remain focussed on the fact that the learner must be able to successfully fulfil the outcomes within 100 hours of effort (if 5 ECTS Credit module). The module content and the associated modes of delivery should then be considered. The content should be sufficient as to allow the learner to meet all the prescribed learning outcomes for the module. The mode of delivery and the allocation of time to the various elements should be such as to enhance the learning experience of the student and ensure outcomes can be met. Text books (both class texts and reference texts) should be identified and listed within the module descriptor. One of the most critical parts of the module development is module assessment. It is important that the assessment methods chosen for each of the elements are adequate and can measure the learner’s performance/abilities in relation to the learning outcomes. Presenting evidence of how the learner meets the learning outcomes is crucial during accreditation.

The top-down approach described ensures that the programme developed delivers graduates who are flexible within, and can adequately engage in, a wide range of roles in the designated industry sector. The layout and presentation of the module descriptor in the programme documentation is of critical significance and should be allocated significant attention. A coherent synchroncity should exist between the modules developed, their accompanying learning outcomes, and the programme outcomes as specified by Engineers Ireland.

DOCUmentation FOR ACCREDITATION

Programme documentation includes detail on all aspects of the programme such as programme objectives, module descriptors, facilities available to run the programme as well as other programme specific information. A document must also be produced by the programme committee which includes important detail specific to the accreditation procedure, and in particular, how the programme performs in relation to the EI programme outcomes. The general structure of this report is as specified by EI [1] but the layout/presentation of the information is at the discretion of the programme committee. The area most worthy of consideration/debate is in relation to section f) Analysis & Implementation of Programme Outcomes. This section must detail how the programme committee believe that the programme is satisfying the EI programme outcomes. This should also detail the manner in which compliance with the outcomes manifests itself as well as identifying the location of the relevant evidence. Some suggestions on how best to negotiate this aspect of the accreditation are summarised in this section and are based upon personal observation/opinion and feedback from the process.

Keating et al [3] introduce a matrix format for identifying and presenting evidence of EI programme outcome compliance. A modified version of this was utilised in this Level 7 programme accreditation (Table 1). The matrix has the potential to easily illustrate a programmes’ performance in relation to programme areas and outcomes. The cells of this matrix are populated with the learning outcomes which are considered by the lecturer/module author delivering the module to be contributing towards learning under the particular programme outcome in a specific programme area. For example cell (a)(1) could be populated as follows, MECT 2103 L.O. 1-4, 6; where MECT 2103 is the module code. This suggests that learning
outcomes 1, 2, 3, 4 & 6 are contributing to programme outcome (a) in programme area (1). A programme matrix can then be generated which is populated with all contributing learning outcomes in the appropriate cells. This is a useful means of identifying potential ‘gaps in learning’ in a programme. This is highlighted by a sparsely populated matrix or cells containing very few or no learning outcomes.

<table>
<thead>
<tr>
<th>Programme Areas</th>
<th>Engineers Ireland Programme Outcomes</th>
</tr>
</thead>
<tbody>
<tr>
<td>MECT 2103</td>
<td>(a)</td>
</tr>
<tr>
<td>(1)</td>
<td></td>
</tr>
<tr>
<td>(2)</td>
<td></td>
</tr>
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<td>(3)</td>
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<td>(4)</td>
<td></td>
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<td>(5)</td>
<td></td>
</tr>
<tr>
<td>(6)</td>
<td></td>
</tr>
</tbody>
</table>

**Table 1: Programme Outcomes/Areas Matrix Format for an Individual Module**

Overall performance* of the programme w.r.t. to programme outcomes could be as in Table 2;

<table>
<thead>
<tr>
<th>Module Code</th>
<th>Module Title</th>
<th>% a</th>
<th>% b</th>
<th>% c</th>
<th>% d</th>
<th>% e</th>
<th>% f</th>
<th>% g</th>
</tr>
</thead>
<tbody>
<tr>
<td>MATH 1103</td>
<td>Mathematics 1</td>
<td></td>
<td></td>
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<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>MECH 1103</td>
<td>Mechanical Systems 1</td>
<td></td>
<td></td>
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<td>Etc..</td>
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<tr>
<td></td>
<td>Stage One Averages</td>
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<td></td>
<td>Stage Two Averages</td>
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<tr>
<td></td>
<td>Stage Three Averages</td>
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<tr>
<td></td>
<td>Programme Averages</td>
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<td></td>
</tr>
</tbody>
</table>

**Table 2: Summary of Programme Performance w.r.t. EI Programme Outcomes**

*The percentage performance is gained from the ratio of the number of learning outcomes which are specifically satisfying the prescribed programme outcome to the total number of learning outcomes for that module.

It is worthy of noting that this method does not identify the extent or quality of the contribution as each learning outcome is assigned equal value. Section f) could begin with this table as a means of an introduction to the evaluation. This table can then be followed by an essay-type evaluation of the performance of the programme under the heading of each EI programme outcome individually. This involves examination of the module matrices produced by the individual delivering the module and reading through the module descriptors for the programme. This should include detail on how the modules and ultimately the programme satisfy the EI programme outcome requirements. The particular matrix column pertaining to the specific EI programme outcome should be contained within this section for reference and cross-checking by the panel member. The realisation of the suggested format can be quite time consuming but can be rewarded by the increased clarity achieved during the accreditation visit.

**THE ACCREDITATION VISIT**

The objective of the accreditation panel is to ensure that the programme in question is of sufficient standard for the allocation of the status of Associate Engineer of EI. The most
important aspect of this is that they identify evidence of the programme’s (and ultimately the graduate’s) performance in relation to the EI programme outcomes. Therefore, the onus is on the programme committee to ensure that there is sufficient evidence of the satisfaction of each of the seven programme outcomes within the programme areas. The matrix methodology introduced in the previous section is of enormous benefit in streamlining the information pertaining to the EI programme outcomes/areas. Various approaches can be taken to simplify the task of the accreditation panel as far as is possible. The method adopted (in presenting the evidence) during the accreditation of the programme in DIT was closely tied to the matrix illustrated in Table 1. 42 boxes (one for each cell of the matrix) were laid out in a fashion similar to shape of the matrix. These boxes each contained the information/evidence ‘backing up’ each learning outcome contained within the cell location. The evidence was presented as follows;

- A copy of the module descriptor (just the relevant page(s)) with the particular learning outcome(s) identified using a highlighter pen.
- The examination paper/student instruction/project outline, relevant part highlighted.
- The exam script/laboratory report/thesis or other with the relevant detail highlighted.

Paper clips were used to hold the material together and this was then placed in the relevant box. This method worked fairly well with the information being easily accessible/available to the panel. However, on the basis of both being involved in this process and from feedback from the panel, an alternative strategy is now suggested. The process would be simplified if 21 boxes (7 boxes per stage of the 3 stage programme) only were used which contained information pertaining to each of the 7 EI programme outcomes. This, in conjunction with reference to the programme matrix, should suffice.

CONCLUSIONS
Professional accreditation of engineering programmes is the only means of ensuring that consistently high quality programmes are being delivered to the learners engaging on our 3rd level programmes. The EI programme outcome approach to programme development greatly enhances the prospects of developing programmes which can make a real contribution to the various existing and emerging sectors in the modern world. This paper outlined some approaches which can be adopted during the module development stage within the programme outcome framework/structure. These approaches can be very helpful in generating a suite of module descriptors which are consistent in terms of layout and quality. This is useful to both learner and lecturer and can enhance the ‘student-centred-learning’ approach to education. Based on experienced gained during the accreditation of our programme some suggestions have been outlined which can aid in the preparation for, and facilitation of, accreditation of Level 7 programmes (or other) using the programme outcome approach. This may be particularly beneficial to those in the third-level sector involved in similar accreditations in the near future.

REFERENCES
2. ‘Accreditation Criteria for Engineering Education Programmes’ Engineers Ireland.
DORAS – INCREASING THE VISIBILITY AND IMPACT OF DCU RESEARCH

Rachel Hill

Library, Dublin City University, Ireland
Email: rachel.hill@dcu.ie

ABSTRACT
This paper gives an overview of DORAS – an online open access repository of research papers from Dublin City University – and explores how repositories like DORAS are increasing the visibility, and potentially the impact, of research output from educational institutions. In this paper the main motivations for authors to deposit papers in DORAS are identified: increasing the accessibility of papers, increasing the visibility of papers on search engines and web portals, promotion of cutting-edge research, and the need to comply with research councils' policies on open access.

INTRODUCTION
DORAS is an online collection of research papers from Dublin City University (DCU) and is available at http://www.doras.dcu.ie. It contains a growing number of journal articles, conference papers, books, book chapters, and theses from DCU authors. Most of these papers are open access, meaning that the full-text can be viewed online by anyone with internet access. The full-text papers are also indexed by search engines, thus making them easily searchable and retrievable using websites such as Google, Yahoo! and Google Scholar.

INSTITUTIONAL REPOSITORIES
Open access collections of research such as DORAS are known as Institutional Repositories (IRs). Over the last decade institutions have been developing IRs as a means of preserving and promoting their research output across the globe. Put simply, an IR is a website containing one or more collections of full-text papers from a specified academic community. These papers are generally online and free to use by any member of the public.

Depositing papers in an IR is both beneficial to the individual authors and the institutions to which they belong. The main drivers for depositing research in an IR are to:
- Raise the profile of an author’s/institution’s research internationally
- Increase the visibility and accessibility of an author’s/institution’s research online
- Increase the impact of research
- Meet the requirements of research councils’ open access policies
- Organise and preserve the papers perpetually

INCREASED ACCESS TO PUBLISHED RESEARCH
One of the major advantages of DORAS, and IRs in general, is that they increase the accessibility of research publications from the institution. Having access to published papers is crucial to the process of undertaking and completing research. Each year academic libraries pay
out hefty subscription fees in order to enable academics to access journal and publisher databases online. If the institution cannot afford the subscription fees then its researchers are at a loss. This also means that when an author publishes a research article, its audience is limited to those who have paid a subscription to the publication in which the article appears. This is limiting the readership of the article, and in turn it may affect the impact of the article.

In contrast to publisher databases, DORAS can be accessed free of charge. This means that it can reach a wider audience. Over the last decade, due to the influence of the Open Access movement, many publishers have started to permit their journal articles to be made open access and deposited in IRs like DORAS. There are normally some conditions to this: many publishers will allow a peer-reviewed version of a journal article to be deposited in an IR but they will not permit the final copy-edited and formatted version to be made open access; many publishers specify that an article cannot be made open access until several months after publication; in some cases the publishers will only permit journal articles to be made open access if the author pays a one-off open access fee. SHERPA, a UK service that lists the open access policies of over 400 international publishers, states that 68% of these publishers permit their publications to be made open access in some form [1]. In most cases, the only barrier that stands between an author making his/her research open access is the time and effort required to upload the paper to the institutional repository. In the case of DORAS, DCU Library uploads the papers on behalf of the author. This means that all an author has to do is email the file(s) to the Library who will then check the paper for copyright clearance and upload the file(s) and bibliographic information associated with the paper.

SEARCH ENGINE VISIBILITY

Another key benefit to depositing research in an IR is that it increases the visibility of the research online. For the first half of 2008 68% of traffic to the DORAS website came via search engines. DORAS is structured in a web-friendly manner that makes it easy for search engine robots to crawl and index the web pages and full-text files. It is no surprise that Google is the predominant search engine used to access the DORAS website. Approximately two thirds of users accessing DORAS through search engines use the Google search engine.

In order to illustrate the high visibility of DORAS papers on Google, a random sample of 50 papers from DORAS was selected. The title of each paper was inputted in the www.google.com [2] search engine and the search results were analysed to investigate:

- DORAS’ ranking on the search results page
- DORAS’ ranking compared to the official publisher/conference website for the paper
- The highest ranked result that linked to an open access full-text version of the paper

It was found that in 52% (26) of the searches carried out, DORAS ranked first on the search results page (Figure 1). In fact, DORAS only ranked below the top ten in 2 of the title searches.
Figure 1: Ranking of DORAS papers on Google search results page.

Figure 2 shows an example of one of the searches carried out in Google. The journal article title, *Demonstration of wavelength packet switched radio-over-fiber system*, was inputted in the search engine. In this search, DORAS was the top hit on the search results page. Significantly, DORAS ranked higher than the journal publisher’s website.

Figure 2: Google search for the title of a journal article that is available in DORAS (at http://doras.dcu.ie/163/)

Overall, in 28 (56%) of the searches, the DORAS version of the paper ranked higher on the search results page than the official publisher/conference website for the paper. Moreover, in 39 (78%) of the searches, DORAS was the highest ranked link to an open access version of the paper. While these results are anecdotal, given that Google is constantly evolving, they give a snapshot of the high visibility of DORAS papers on Google. Although it is more difficult to
quantify, similar patterns can be seen when using Google to search for particular subjects or authors that are found in DORAS.

**PROMOTING CUTTING-EDGE RESEARCH**

Institutional repositories provide the means for researchers to increase access to valuable research papers that are not published in journals or books. These papers - including theses, conference proceedings, workshop papers, working papers and reports – often contain breaking research and prime intellectual content. By depositing them in an IR, authors are not only increasing the visibility of their research but they are also broadening the potential for inter-institutional collaboration.

**Theses**

In DCU a one year e-theses pilot with the Schools of Biotechnology and Electronic Engineering was completed in the academic year 2007/2008. Postgraduates submitting research masters or PhD theses were required to deposit an electronic version of their theses in DORAS. Overall this pilot was successful and from Autumn 2008 all research theses submitted for award in DCU will also be uploaded to DORAS. The advantages of making theses open access online are apparent – traditionally theses have been highly inaccessible, in a lot of cases gathering dust in library basements and academics’ offices. Since the dawning of the Web it has been possible for postgraduates to make their finished theses available online on personal websites, departmental websites, etc. But without the structures and processes formalised there is no guarantee that the thesis will remain available permanently, or that the files online are the definitive version of the thesis.

In advocating the use of DORAS for exposing theses and other unpublished papers, DCU has made an organisational commitment to promoting the entire research output from the university as well as preserving this material so that future students and academics can build on the research already completed in the university.

**NATIONAL AND EUROPEAN INITIATIVES THAT ARE BROADENING ACCESS TO DCU RESEARCH**

Underpinning the structure of an IR is a protocol that allows the bibliographic metadata describing papers in an IR to be harvested from the IR and used in external value-added services. In the case of DORAS, there are three particular external services that are increasing the visibility and accessibility of DORAS papers online, namely, IReL-Open, DART-Europe and DRIVER.

**IReL-Open**

IReL-Open is an Irish institutional repository initiative run by the Irish Universities Association (IUA) Librarians’ group with Higher Education Authority (HEA) funding [3]. The aim of this three year project is to establish IRs in all Irish universities and to create a national portal that will harvest papers from each IR, including DORAS. This portal will enable users to browse and cross-search all the open access research in Irish IRs from the one location. The national portal will be operational by the end of 2010. Once complete, it has the potential to raise the profile and impact of Irish research internationally.
**DART-Europe**

DART-Europe is a European organisation made up of approximately 120 institutions, including DCU. DART-Europe has created a portal that harvests doctoral theses from the IRs in these institutions. The portal is available at [http://www.dart-europe.eu](http://www.dart-europe.eu). Approximately 100,000 doctoral theses are currently being harvested into the portal, including theses from DORAS. This rapidly growing portal is not only raising the profile of DCU research in Europe but it is also an invaluable resource that can be used by PhD students and researchers.

**DRIVER**

DRIVER is another European initiative that is harvesting papers from DORAS. DRIVER is an FP7 funded project with a main objective to “build a virtual, European scale network of existing institutional repositories using technology that will manage the physically distributed repositories as one large scale virtual content source” [4]. The DRIVER project has created a test bed portal containing over 600,000 open access papers from 110 repositories across Europe. This portal can be accessed from [http://driver-community.eu](http://driver-community.eu). Users can search and browse DORAS papers from the DRIVER portal. In this way it is acting as another route through which people can access DCU research.

**RESEARCH COUNCILS’ OPEN ACCESS POLICIES**

Much of the research carried out in an academic institution is funded by research councils and funding bodies. Given the benefits of open access it is no surprise that a growing number of research councils are requiring that their funded research is made public online. The most common methods for complying with these policies are either to deposit the research papers in an institutional repository or in a subject repository. In Ireland a number of research councils have developed, or are in the process of developing, a policy on open access. IRCSET, the Irish Research Council for Science, Engineering and Technology, recently announced an open access policy which took effect from 1st May 2008 [5]. The conditions of the policy can be seen in Table 1.

<table>
<thead>
<tr>
<th>Conditions to which IRCSET funded Award Recipients should adhere:</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. All researchers must lodge their publications resulting in whole or in part from IRCSET-funded research in an open access repository as soon as is practical, but within six calendar months at the latest.</td>
</tr>
<tr>
<td>2. The repository should ideally be a local institutional repository to which the appropriate rights must be granted to replicate to other repositories.</td>
</tr>
<tr>
<td>3. Authors should deposit post-prints (or publisher’s version if permitted) plus metadata of articles accepted for publication in peer-reviewed journals and international proceedings;</td>
</tr>
<tr>
<td>4. Deposit should be made upon acceptance by the journal/conference. Repositories should release the metadata immediately, with access restrictions to full text article to be applied as required. Open access should be available as soon as practicable after the author-requested embargo, or six month, whichever comes first;</td>
</tr>
<tr>
<td>5. Suitable repositories should make provision for long-term preservation of, and free public access to, published research findings.</td>
</tr>
<tr>
<td>6. IRCSET may augment or amend the above requirements wherever necessary to ensure best practice in Open Access.</td>
</tr>
</tbody>
</table>

Table 1: Excerpt from the IRCSET statement of policy relating to the open access repository of published research papers [5].
The IRCSET policy is very similar to draft policies recently drawn up by Science Foundation Ireland (SFI) and the Higher Education Authority (HEA). It is anticipated that these policies will take effect soon. A list of research council policies on open access can be viewed at http://www.sherpa.ac.uk/juliet/

CONCLUSIONS
This paper has highlighted the benefits of open access repositories like DORAS. The main advantages for authors and institutions is that their research is more accessible and visible online. This in turn leads to an increased “web presence” for the research papers, the authors who write them, and the institutions to which they belong. Much research is now being conducted into the impact of open access on citations [6]. While this may vary from discipline to discipline there is a general indication that open access papers are more highly cited than papers that are only available by subscription. The high visibility of DORAS on Google, as mentioned above, gives weight to the argument that open access has a positive effect on impact.

While still at the early stages, it can be envisaged that repositories like DORAS will grow in value as more researchers deposit papers in them – for their own benefit, as well as a means to complying with research funders’ open access policies.

REFERENCES

5. The Irish Research Council for Science, Engineering & Technology statement of policy relating to the open access repository of published research papers. Available at: http://www.ircset.ie/news/releases/080501_OpenAccessPolicy.html Accessed 15/07/08
ABSTRACT
A project was carried out in the Department of Process & Chemical Engineering at University College Cork to formulate the learning outcomes of the BE degree in Process & Chemical Engineering and to communicate these to the undergraduate students. The first part of the project was a survey that showed the undergraduate students had a poor knowledge of the learning outcomes concept and the application of learning outcomes within their degree programme. The second part of the project formulated 20 learning outcomes for the degree programme. These were formulated from reviewing professional accreditation documents. Then, a presentation was created and presented to first year and finally year students. These students were surveyed at the end of the presentation and most of the students found the session to be very beneficial.

INTRODUCTION
Learning outcomes are action statements describing what a student is capable of demonstrating in terms of knowledge, understanding, skills and attitudes after completion of a learning activity. International trends in education show a shift from the “teacher-centred” approach to a “student-centred” approach [1]. This alternative model focuses on what the students are expected to be able to do at the end of a module or programme. Hence, this approach is referred to as an outcomes-based approach, where learning outcomes are used to express what students are capable of doing at the end of the learning period. In the EU with the implementation of the Bologna Process by 2010, all modules and programmes throughout the participating countries will be expressed using learning outcomes. Furthermore, accreditation bodies, such as Engineers Ireland (EI) and the Institution of Chemical Engineers UK (IChemE) use this learning outcomes approach in accrediting degree programmes [2, 3].

In early 2007, a “knowledge of learning outcomes questionnaire” was given to years 1, 2, 3 and 4 in the undergraduate degree programme in Process & Chemical Engineering at University College Cork (UCC) [4]. The questionnaire strived in-part to evaluate the following:

- Their knowledge of the learning outcomes concept.
- Their knowledge of the degree programme learning outcomes.
- Had anyone talked to them about the degree programme learning outcomes.

The conclusions were as follows:
The concept of learning outcomes was not clear to most of the students. There was a need to educate the students about the learning outcomes concept, considering its recent adoption in UCC and the importance of learning outcomes within teaching & learning in general. The learning outcomes of the degree programme in Process & Chemical Engineering were not clear to most students. Even though programme learning outcomes exist in accreditation documentation; there is a need formulate them in a “student friendly” format and to communicate them to students. Furthermore, there is a need to explain how module outcomes are striving to help them attain the programme outcomes.

FORMULATION OF DEGREE PROGRAMME LEARNING OUTCOMES

Following the survey, the formulation of the degree programme learning outcomes was undertaken in summer 2007. A first draft document was created and it consisted of 19 learning outcomes. These learning outcomes were created after reviewing the following documentation:

- Learning outcomes used in the guide-lines for accreditation of engineering undergraduate degree programmes by the Institution of Engineers of Ireland [IEI].
- Learning outcomes used in the guide-lines for accreditation of chemical engineering degree programmes by the Institution of Chemical Engineers, UK [IChemE].
- Accreditation document submitted to IEI by the Department of Process & Chemical Engineering UCC. This was as part of an application for full accreditation with the Institution.
- Accreditation document submitted to IChemE by the Department of Process & Chemical Engineering UCC. This was as part of an application for full accreditation with the Institution.

The 19 learning outcomes that were formulated were classified under the following 8 headings:

1. Knowledge and Understanding of Mathematics, Science & Core Chemical Engineering
2. Problem Solving
3. Social, Environmental and Economic Context
4. Engineering Design
5. Other Practical / Transferable Skills
6. Working as an Engineer in Practice
7. Research Skills
8. Additional Knowledge and Skills

As an example, a learning outcome under Engineering Design is presented in Figure 1. It also highlights the relevant modules that are involved in trying to achieve this and type of assessments applied.

The draft document was then circulated to the staff within the Department who lectured on the degree programme for their input. The staff gave their input through written comments and face to face meetings. The second draft incorporated the input from staff.
In academic year 2007/08, the second draft was used as the basis for the creation of a presentation to be made to the first year and fourth year students. From giving the presentation and from feedback from the students, it was obvious that one of the learning outcomes was too broad and was consequently broken down into two learning outcomes, resulting in the third draft which consists of 20 learning outcomes. The major features of the document are as follows:

- Definition of the learning outcomes concept and its usefulness.
- Statement of the 20 degree programme learning outcomes.
- Description of how the individual modules and their assessment are related to the degree programme learning outcomes.
- Provision of a short section which tries to relate the achievement of the degree with careers within the core of process and chemical engineering and to other career opportunities.

**Engineering Design**

11. To perform process design of unit operations. This includes the following abilities:

- Evaluation of operating variables.
- Sizing of the equipment.
- Evaluating any utility requirements, such as electrical power, heating, cooling etc.
- Perform sensitivity / optimisation analysis of how variation in input variables influence the performance of the unit operation.
- Creation of P&ID.

**Relevant modules**

PE 2001 / 2003 / 3002 / 3003 / 3006 / 4008

**Methods of assessment**

Methods of assessment are final exam plus the following:

- PE 2003: Process design of a heat exchanger
- PE 3006: Process design of a reactor
- PE 4001: Design of a unit operation
- PE 4008: Process design calculation assignments for a bioreactor & bioseparator
- PE 4006: The design project will involve the process design of unit operations

**Figure 1:** Example of a degree programme learning outcome

**COMMUNICATING WITH THE STUDENTS**

In the later part of 2007, a PowerPoint presentation, based on draft 2 of the learning outcomes document, was presented to the first year and fourth students. The students were also given the document at the beginning of the session. At the end of the session, a short questionnaire was given to the students to quantitatively evaluate if they had gained a better understanding of the learning outcomes concept, the degree programme learning outcomes and to gauge if they considered this type of session to be of any benefit to them.

The first three questions on the questionnaire along with analysis of the student responses is presented below for the first year and fourth year students, along with conclusions based on these
data. 26 of the 30 first year students attended the presentation and were surveyed afterwards. Analysis of their responses is presented below:

**Q1. How would you rate your level of confidence in being able to explain the concept of a learning outcome to another person?**

**Q2. How would you rate your level of confidence in being able to write down the Learning Outcomes of your degree programme?**

Quantitative data on the responses of the first year students to Q1 and Q2 are presented in Figure 2.

![Figure 2: Responses of first year students in 2007/2008 to Q1 and Q2.](image)

From this:
- 96% of students were confident of explaining the learning outcome concept.
- 65% of students were confident that they could write down most of the learning outcomes of the degree programme while 35% are unsure. None had poor confidence.
- These data represent a major improvement in the understanding of learning outcomes and the degree programme learning outcomes where only 30% expressed confidence when initially surveyed prior to the presentation in 2007.

**Q3. How would you rate the session and document on Learning Outcomes?**

All students found the session beneficial with 65% rating it as very useful and 35% rating it as useful. None of the students were unsure of the usefulness of the session or rated it as a waste of time. A number of the students expressed the view that the session gave them a very good insight into 2nd, 3rd and 4th years.

Only 11 of the 25 fourth year students attended the presentation and were surveyed afterwards. Analysis of their responses to the questions is similar to the first years and is presented below:
• 82% of students were confident of explaining the learning outcome concept. 18% were still unsure while none expressed poor confidence. This represents a major improvement on the initial survey prior to the presentation where 48% were confident, 33% not sure and 14% were not confident.

• 73% of students were confident that they could write down most of the learning outcomes of the degree programme while 18% were unsure and 9% had poor confidence. This represented a major improvement on the initial survey prior to the presentation where only 24% expressed confidence, 38% were unsure and 38% were not confident.

• 10 of the 11 students found the session beneficial with half of these rating it as very useful and half rating it as useful. One student was unsure of the usefulness of the session.

CONCLUSIONS

The undergraduate students in the Department of Process & Chemical Engineering, UCC had a poor understanding of the learning outcomes concept, when initially surveyed at the beginning of this project. The presentation given to the students on the programme learning outcomes greatly improved their understanding of learning outcomes.

The students initially had a poor knowledge of the degree programme learning outcomes. Even though programme learning outcomes existed in accreditation documents, these were not communicated to the students. This acted as a motivation to create a document and a presentation that outlined the programme learning outcomes of the degree programme and to highlight the modules that were striving to achieve them. This programme learning outcomes presentation was given to the first and fourth year students and greatly improved their knowledge of the programme learning outcomes.

The students rated highly the presentation and stated that is was beneficial to them.

For the first year students, the presentation also represented a “mapping out” of the whole degree programme in addition to communicating to them what they should achieve during their four years. It gave them a much clearer picture of what lay ahead for them in years 2, 3 and 4. It gave them a much greater connection to the core discipline of chemical engineering.

Based on the above, it was decided to provide the programme learning outcomes presentation and document to the first year and fourth year students on an annual basis moving into the future. The first years will receive this presentation as an integral part of a first year module (PE 1003 Introduction to Process Engineering). It is envisaged that the fourth year presentation would contain a summary of the learning outcomes with more emphasis on linking the learning outcomes to career opportunities within chemical engineering and elsewhere. It will also emphasise the types of skills that are not well covered in College and are better learned on the job. It is also envisaged to obtain more feedback from the students by inviting other staff members to participate in an open discussion with them towards the end of the presentation session.
Even though this was a small study, it is possibly true to state that some of the conclusions may be relevant to other engineering degree programmes in Ireland. In particular, the need to formulate and communicate programme learning outcomes to students and to discuss the benefits they can gain from this activity.

REFERENCES
2. The Institution of Engineers of Ireland, Accreditation criteria for engineering education programmes, 2003.
RESPONSES OF ENGINEERING STUDENTS TO LECTURES USING POWERPOINT

Aidan O’Dwyer

School of Electrical Engineering Systems, Dublin Institute of Technology, Ireland
E-mail: aidan.odwyer@dit.ie

ABSTRACT
This contribution reports on, reflects on and evaluates engineering students’ responses to the use of PowerPoint in a lecture environment, compared to a more traditional lecturing approach. The contribution concludes that, on average, students value PowerPoint based lectures both as a means of better understanding the material and for the medium’s structural and organisational advantages. Students also strongly favour the PowerPoint lectures being available on-line and that a paper copy of the PowerPoint presentation be distributed at the lecture.

INTRODUCTION
There is increasing emphasis placed on the electronic delivery of lecture material, typically by means of PowerPoint presentations. This is driven by investment in the required IT equipment (data projectors and computers), the use of online environments (such as WebCT) and the reduction, in engineering, in class contact hours. Despite these driving factors, the use of PowerPoint in lectures has not been analysed in detail in the engineering education literature. Some authors in this literature analyse the changes in standardised test scores as a result of moving to a PowerPoint delivery mechanism (e.g. [1]); other authors are content with providing tips for effective PowerPoint presentations (e.g. [2–4]), avoiding ‘death by PowerPoint’ ([2, 3]). In particular, surveys of engineering student perceptions of the advantages and disadvantages of a lecturing approach that uses PowerPoint for a substantial part of the lecture material, compared to a more traditional lecturing approach using a blackboard or an overhead projector, are absent. There exists some analysis in the wider educational literature of the perceptions of (typically) humanities students obtained using structured surveys ([5–8]).

In this contribution, the responses of three engineering student cohorts at Dublin Institute of Technology to the use of PowerPoint (and associated on-line material on WebCT), are assessed using a questionnaire influenced by previous work ([5–8]). The questionnaire was distributed at the end of the semester in all cases. The questionnaire, provided in Appendix 1, uses a 5-point Likert scale, with 1 corresponding to ‘strongly disagree’ and 5 corresponding to ‘strongly agree’. Following the lead of [5], the questionnaire is constructed with alternating positive and negative questions to avoid directional bias. For example, in the first question students were asked to indicate whether PowerPoint lectures are more attention capturing than traditional lectures (positive direction). Then, in the second question, they were asked to indicate whether PowerPoint lectures are less interesting than traditional lectures (negative direction). The negative items are reversed for scoring.

The three engineering student groups surveyed were a Level 7, Year 1 group in Electrical Engineering studying basic electrical engineering (labelled D0), a Level 8, Year 4 group in
Electrical Engineering studying process control (labelled D4) and a Level 9 group in Engineering studying process control (labelled D9). In all cases, students were provided with a paper copy of the presentation prior to the material being covered, and the presentation itself was also previously placed on-line (on WebCT). Approximately 65% of the lecture time of the Level 7 group and 75% of the lecture time of the Level 8 and 9 groups were devoted to lecturing through PowerPoint.

**STUDENT FEEDBACK FROM THE STRUCTURED QUESTIONS**

The mean values of the responses to the survey questions were compared (between the student cohorts); this data is provided in Tables 1-3. In addition, a weighted average of all responses, obtained from nineteen D0 responses, twelve D2 responses and five D9 responses, equivalent to 48% of the total student cohort, was determined, and is labelled WA in Tables 1-3. For ease of analysis, student responses are ranked according to this weighted average figure.

<table>
<thead>
<tr>
<th></th>
<th>D0</th>
<th>D2</th>
<th>D9</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I like that a paper copy is also available of the PowerPoint slides</td>
<td>4.4</td>
<td>4.7</td>
<td>4.6</td>
<td>4.5</td>
</tr>
<tr>
<td>I like that the PowerPoint slides are available for viewing on WebCT</td>
<td>4.4</td>
<td>4.7</td>
<td>4.6</td>
<td>4.5</td>
</tr>
<tr>
<td>I generally find visual elements (e.g. pictures/charts/graphics) helpful in the PowerPoint presentations</td>
<td>4.3</td>
<td>4.5</td>
<td>4.4</td>
<td>4.4</td>
</tr>
<tr>
<td>I find PowerPoint based lecture notes easier to understand</td>
<td>4.4</td>
<td>4.0</td>
<td>4.0</td>
<td>4.2</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures are better structured and prepared</td>
<td>4.1</td>
<td>4.3</td>
<td>3.6</td>
<td>4.1</td>
</tr>
<tr>
<td>With PowerPoint based lectures, I find that my notes are more organised</td>
<td>4.1</td>
<td>4.4</td>
<td>3.0</td>
<td>4.1</td>
</tr>
<tr>
<td>I prefer it when important definitions and terms are completely written out on the PowerPoint slides</td>
<td>4.2</td>
<td>3.8</td>
<td>4.4</td>
<td>4.1</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures are easier to follow</td>
<td>4.0</td>
<td>4.0</td>
<td>3.8</td>
<td>4.0</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures means that the lecturer stays more focused on the lecture material (i.e. he did not skip around or go on tangents)</td>
<td>3.9</td>
<td>4.1</td>
<td>3.8</td>
<td>4.0</td>
</tr>
<tr>
<td>I find it helpful for the lecturer to use the PowerPoint slides as a basis for the lecture, adding examples and elaborating beyond the slides on the key points</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
<td>4.0</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures better emphasise the important points</td>
<td>3.8</td>
<td>3.9</td>
<td>4.0</td>
<td>3.9</td>
</tr>
<tr>
<td>I am satisfied with the print size on the paper copy of the slides, as I know that the full sized information is available on WebCT</td>
<td>3.5</td>
<td>4.2</td>
<td>4.4</td>
<td>3.9</td>
</tr>
<tr>
<td>I generally prefer slides that provide the full text of the lecture material (i.e. everything that the lecturer wants me to know is completely written out on the slide)</td>
<td>3.9</td>
<td>3.9</td>
<td>4.0</td>
<td>3.9</td>
</tr>
<tr>
<td>I find it helpful for the lecturer to read the PowerPoint slides as they are presented</td>
<td>4.3</td>
<td>3.5</td>
<td>3.6</td>
<td>3.9</td>
</tr>
<tr>
<td>I wish PowerPoint slides were used for lecturing in all subjects</td>
<td>4.1</td>
<td>3.6</td>
<td>3.8</td>
<td>3.9</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures are visually more clear</td>
<td>3.9</td>
<td>4.0</td>
<td>3.0</td>
<td>3.8</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures allows the lecturer to better use the lecture time to balance lecture and discussion (or problem solving)</td>
<td>3.8</td>
<td>3.7</td>
<td>4.2</td>
<td>3.8</td>
</tr>
<tr>
<td>I find I use a textbook less when the lecturer uses PowerPoint slides</td>
<td>3.8</td>
<td>3.6</td>
<td>4.2</td>
<td>3.8</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures are more interesting</td>
<td>3.7</td>
<td>3.6</td>
<td>3.8</td>
<td>3.7</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures mean that I learn more in the lectures</td>
<td>3.7</td>
<td>3.8</td>
<td>3.6</td>
<td>3.7</td>
</tr>
<tr>
<td>It was easy for me to access WebCT</td>
<td>3.4</td>
<td>4.0</td>
<td>4.4</td>
<td>3.7</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures mean that there is more motivation for me to come to lectures</td>
<td>3.8</td>
<td>3.1</td>
<td>3.8</td>
<td>3.6</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures are more attention capturing</td>
<td>3.7</td>
<td>3.2</td>
<td>3.6</td>
<td>3.5</td>
</tr>
</tbody>
</table>
This table corresponds to student agreement or strong agreement with the relevant statements. There is broad agreement, with some difference in emphasis, between students on the three programmes surveyed. Clearly, all students value PowerPoint based lectures both as a means of better understanding the material and for the medium's structural and organisational advantages. On average, students suggest that PowerPoint based lectures are more interesting and facilitate greater learning (than a more traditional approach). These advantages also emerge from the students' unscripted comments (see next section). It is also clear that students favour the presentations being available on-line, with a paper copy of the material being available during the lecture. The following differences in emphasis are evident:

- Level 9 students are less likely to report that their notes are more organised when PowerPoint is used, perhaps because these postgraduate students have developed organisational skills to a higher extent than the undergraduate students surveyed.
- Level 7 and Level 8 students favour visual elements in PowerPoint presentations, reflecting the strongly visual learning style of this cohort of students.
- Level 7 students are less confident and engaged with WebCT, perhaps due to inexperience.

<table>
<thead>
<tr>
<th></th>
<th>D0</th>
<th>D2</th>
<th>D9</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find that PowerPoint based lectures maintain my focus and interest in the lecture material for a longer time</td>
<td>3.7</td>
<td>3.0</td>
<td>3.4</td>
<td>3.4</td>
</tr>
<tr>
<td>I find I enjoyed the class more when PowerPoint lectures are used</td>
<td>3.5</td>
<td>3.3</td>
<td>3.2</td>
<td>3.4</td>
</tr>
<tr>
<td>I find that PowerPoint based lectures mean that taking notes is easier</td>
<td>3.4</td>
<td>2.8</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>I would prefer if the information is revealed line by line on the slide, rather than if the total information on the slide is given all at once</td>
<td>3.3</td>
<td>2.6</td>
<td>4.0</td>
<td>3.2</td>
</tr>
<tr>
<td>I would like the lecturer to use a consistent colour scheme in the PowerPoint slides within the same lecture</td>
<td>3.2</td>
<td>3.0</td>
<td>3.5</td>
<td>3.2</td>
</tr>
<tr>
<td>When I have a copy of the presentation beforehand, I find it easier for my mind to wander since I have already seen the material</td>
<td>3.1</td>
<td>3.4</td>
<td>3.4</td>
<td>3.2</td>
</tr>
<tr>
<td>I prefer slides that contain pictures, charts or graphs only</td>
<td>3.3</td>
<td>2.3</td>
<td>3.4</td>
<td>3.0</td>
</tr>
<tr>
<td>I feel that the use of PowerPoint slides inhibits discussion in the lecture</td>
<td>2.9</td>
<td>2.8</td>
<td>3.0</td>
<td>2.9</td>
</tr>
<tr>
<td>I would like the lecturer to vary the size and shape of the text used in the PowerPoint slides</td>
<td>3.3</td>
<td>2.4</td>
<td>2.5</td>
<td>2.9</td>
</tr>
<tr>
<td>I feel the lecturer should only give an outline of the lecture on the PowerPoint slides, as I would learn more in the lecture if I had to write some of the material</td>
<td>2.7</td>
<td>3.3</td>
<td>3.0</td>
<td>2.9</td>
</tr>
<tr>
<td>I find it helpful if each slide is revealed all at once, even if it is ahead of the lecture</td>
<td>2.8</td>
<td>2.8</td>
<td>2.6</td>
<td>2.8</td>
</tr>
<tr>
<td>I like it if the lecturer uses electronic sounds that go along with the pictures or concepts that are being presented</td>
<td>2.8</td>
<td>2.3</td>
<td>3.0</td>
<td>2.7</td>
</tr>
<tr>
<td>When I have a copy of the presentation, I am less likely to attend class since I already have the material</td>
<td>2.7</td>
<td>3.0</td>
<td>1.6</td>
<td>2.6</td>
</tr>
<tr>
<td>I find it boring when the lecturer says the same things the PowerPoint slides say</td>
<td>2.2</td>
<td>2.8</td>
<td>3.2</td>
<td>2.5</td>
</tr>
</tbody>
</table>

This table corresponds to students being unsure about the relevant statements. Again, there is broad agreement, with some difference in emphasis, between students on the three programmes surveyed. It is clear that students, on average, are not exercised by style issues (such as varying the size and shape of the text used or the use of electronic sounds). This table corresponds to students disagreeing with the relevant statements. Clearly, students strongly desire a paper copy of the PowerPoint slides, perhaps because additional notes can be added during the lecture (in an active learning mode). Interestingly, the previous finding that students, on average, report somewhat greater motivation to attend the PowerPoint based lectures is contradicted by the
finding that students, on average, did not feel worse when they missed a PowerPoint based lecture compared to when a more traditional lecture was missed. It is interesting that the general, unscripted comments from some students also reveal some uncertainty and dissatisfaction with a predominantly PowerPoint based lecturing approach (see next section).

Table 3: Ranking of student responses below 2.5

<table>
<thead>
<tr>
<th></th>
<th>D0</th>
<th>D2</th>
<th>D9</th>
<th>WA</th>
</tr>
</thead>
<tbody>
<tr>
<td>With PowerPoint based lectures, I felt worse when I missed the</td>
<td>2.4</td>
<td>2.1</td>
<td>2.4</td>
<td>2.3</td>
</tr>
<tr>
<td>lecture compared to lectures where a blackboard or overhead</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>projector are used</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I wish the lecturer would spend less time using PowerPoint</td>
<td>1.9</td>
<td>2.5</td>
<td>2.2</td>
<td>2.1</td>
</tr>
<tr>
<td>slides</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I feel that there is no need for the lecturer to supply a paper</td>
<td>1.4</td>
<td>1.4</td>
<td>1.6</td>
<td>1.4</td>
</tr>
<tr>
<td>copy of the PowerPoint slides, as they are available on WebCT</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

UNSCRIPTED STUDENT FEEDBACK

Table 4 summarises student comments about preferences for PowerPoint based or traditional lectures ($n =$ number of students making the relevant comments).

Table 4: Summary of student feedback – unscripted comments about preferences for PowerPoint based or traditional lectures

<table>
<thead>
<tr>
<th>I like PowerPoint based lectures better because</th>
<th>n</th>
</tr>
</thead>
<tbody>
<tr>
<td>The time is spent understanding the material instead of writing</td>
<td>8</td>
</tr>
<tr>
<td>down notes</td>
<td></td>
</tr>
<tr>
<td>Lectures are clearer and more focused</td>
<td>5</td>
</tr>
<tr>
<td>Lectures are easier to read and understand</td>
<td>4</td>
</tr>
<tr>
<td>Lectures can be obtained from WebCT, even if a class is missed</td>
<td>3</td>
</tr>
<tr>
<td>Lecture notes are well structured and ordered</td>
<td>2</td>
</tr>
<tr>
<td>Lectures keep the attention; nothing is missed</td>
<td>2</td>
</tr>
<tr>
<td>It is easier to follow the material even if I am absent from the class</td>
<td>1</td>
</tr>
</tbody>
</table>

| I like traditional lectures better because                      |    |
| Writing down the material keeps one more alert                  | 2  |
| I find it easier to study from notes that I have written myself  | 2  |
| The blackboard is useful to summarise important points           | 2  |
| It is easier to follow each step in a numerical example          | 1  |
| After a time, the light from the data projector hurts my eyes    | 1  |

| I gain more knowledge from PowerPoint based lectures because    |    |
| Lectures are better structured and easier to follow             | 4  |
| I can add my own notes to the PowerPoint handout                 | 3  |
| Pictures and diagrams on PowerPoint slides are good for         | 2  |
| remembering material                                            |    |
| Reading and listening simultaneously means all important points | 2  |
| are understood                                                   |    |
| Less time is spent on writing notes, giving more time to        | 2  |
| understand the material                                         |    |
| It is easy to focus on colourful well-laid out slides           | 2  |
| (particularly with diagrams)                                    |    |
| I can store the lectures (from WebCT) on my own computer        | 1  |
| Sometimes a lecturers handwriting on a blackboard can be hard to read | 1  |

| I gain more knowledge from traditional lectures because         |    |
| Writing notes makes one listen carefully so nothing is missed   | 3  |
| Writing notes from the blackboard helps me memorise important   | 1  |
| points                                                           |    |
| I learn more by doing, rather than just reading notes           | 1  |

As before, students clearly value the mediums organisational advantages. Some students find that writing lecture notes aids concentration and study; such notes can, of course, be added by students to the PowerPoint document.
Generally, other unscripted student comments about the PowerPoint lectures gathered by the questionnaire are positive (e.g. PowerPoint is a clear way to present scientific material; I find that the classes are more visually stimulating and interesting with the use of PowerPoint and I feel better prepared for the exam; the PowerPoint presentation handouts contains most of the material, making the taking of extra notes easy), with some interesting suggestions (e.g. try to use PowerPoint for half the lecture and use the whiteboard more; perhaps some PowerPoint slides could be left blank and the explanation given in the lectures; sometimes the student is passive in the class and more active learning is desirable); such suggestions are echoed by [4], for example, in which it is recommended that PowerPoint be used for a maximum of 25% of lecture time.

CONCLUSIONS AND FURTHER WORK
On average, students value PowerPoint based lectures both as a means of better understanding the material and for the medium’s structural and organisational advantages. Students also strongly favour the PowerPoint lectures being available online and that a paper copy of the PowerPoint presentation be distributed at the lecture. In particular, visual elements are favoured in the presentations, reflecting the strongly visual learning style of engineering students. It is also reported that a majority of (humanities) students believe that PowerPoint based lecturing is more attention capturing, interesting, visually clear and is better at emphasising important topics than the traditional method of lecturing [5]. These authors suggest that these advantages reflect the flexible features of PowerPoint, the better structuring and preparing of PowerPoint lectures (at least in these studies) and perhaps the novelty of the experience (which, if true, would mean that the advantages of the method could be expected to fade with time).

The benefits for student learning are the most important issue in assessing electronic lecturing, according to [5]. Though the majority of students felt that PowerPoint lectures were beneficial for their learning, it would be interesting, in further work, to compare examination and other assessment results of students exposed to both teaching styles, though other variables would have to be considered (e.g. the academic ability of the students, changes in the examination paper).

REFERENCES
APPENDIX 1: STUDENT QUESTIONNAIRE

The purpose of this questionnaire is to obtain views on the lecture experience in the module. *Thank you for your assistance.*

You are requested to assign a number between 1 and 5 in answer to a series of statements below, with

- 5 – strongly agree
- 4 – agree
- 3 – unsure
- 2 – disagree
- 1 – strongly disagree

Thinking about lectures delivered using PowerPoint slides compared to lectures delivered by writing on the blackboard or using overhead projector slides:

<table>
<thead>
<tr>
<th></th>
<th>1 – strongly disagree</th>
<th>2 – disagree</th>
<th>3 – unsure</th>
<th>4 – agree</th>
<th>5 – strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find that PowerPoint based lectures are more attention capturing.</td>
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<tr>
<td>I find that PowerPoint based lectures are less interesting.</td>
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<tr>
<td>I find that PowerPoint based lectures are easier to follow.</td>
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<td>I find that PowerPoint based lectures are visually less clear.</td>
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<td>I find that PowerPoint based lectures better emphasise the important points.</td>
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<tr>
<td>I find that PowerPoint based lectures mean that taking notes is harder.</td>
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<td>I find that PowerPoint based lectures maintain my focus and interest in the lecture material for a longer time.</td>
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<td>I find that PowerPoint based lectures mean that there is less motivation for me to come to lectures.</td>
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<tr>
<td>I find that PowerPoint based lectures are better structured and prepared.</td>
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<tr>
<td>I find that PowerPoint based lectures mean that I learn less in the lectures.</td>
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<tr>
<td>I find that PowerPoint based lectures means that the lecturer stays more focused on the lecture material (i.e. he did not skip around or go on tangents).</td>
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<tr>
<td>I find PowerPoint based lecture notes harder to understand.</td>
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<td>I find that PowerPoint based lectures allows the lecturer to better use the lecture time to balance lecture and discussion (or problem solving).</td>
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<td>I find I use a textbook less when the lecturer uses PowerPoint slides.</td>
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<td>With PowerPoint based lectures, I felt worse when I missed the lecture compared to lectures where a blackboard or overhead projector are used.</td>
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<td>I find I enjoyed the class more when PowerPoint lectures are used.</td>
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<tr>
<td>With PowerPoint based lectures, I find that my notes are more organised.</td>
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## General comments

I like (a) PowerPoint based lectures or (b) traditional lectures better because

__________________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________________

I gain more knowledge from (a) PowerPoint based lectures or (b) traditional lectures because

__________________________________________________________________________________________________________________________

__________________________________________________________________________________________________________________________

### Thinking about the PowerPoint lectures in this subject:

<table>
<thead>
<tr>
<th></th>
<th>1 - strongly disagree</th>
<th>2 – disagree</th>
<th>3 – unsure</th>
<th>4 – agree</th>
<th>5 – strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I find it helpful for the lecturer to use the PowerPoint slides as a basis for the lecture, adding examples and elaborating beyond the slides on the key points</td>
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<td>I generally find visual elements (e.g. pictures/charts/graphics) helpful in the PowerPoint presentations</td>
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<td>I prefer it when important definitions and terms are completely written out on the PowerPoint slides</td>
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<td>I like that a paper copy is also available of the PowerPoint slides</td>
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<tr>
<td>I like that the PowerPoint slides are available for viewing on WebCT</td>
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<td>I am satisfied with the print size on the paper copy of the slides, as I know that the full sized information is available on WebCT</td>
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<tr>
<td>It was easy for me to access WebCT</td>
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<td>I generally prefer slides that provide the full text of the lecture material (i.e. everything that the lecturer wants me to know is completely written out on the slide)</td>
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<td>I find it helpful for the lecturer to read the PowerPoint slides as they are presented</td>
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<td>I would prefer if the information is revealed line by line on the slide, rather than if the total information on the slide is given all at once</td>
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<td>I like it if the lecturer uses electronic sounds that go along with the pictures or concepts that are being presented</td>
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<tr>
<td>I feel that the use of PowerPoint slides inhibits discussion in the lecture</td>
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</table>

[please turn over]
<table>
<thead>
<tr>
<th></th>
<th>1 - strongly disagree</th>
<th>2 – disagree</th>
<th>3 – unsure</th>
<th>4 – agree</th>
<th>5 – strongly agree</th>
</tr>
</thead>
<tbody>
<tr>
<td>I would like the lecturer to vary the size and shape of the text used in the PowerPoint slides</td>
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<td>I wish PowerPoint slides were used for lecturing in all subjects</td>
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<td>I would like the lecturer to use a consistent colour scheme in the PowerPoint slides within the same lecture</td>
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<td>I find it helpful if each slide is revealed all at once, even if it is ahead of the lecture</td>
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<tr>
<td>I feel that there is no need for the lecturer to supply a paper copy of the PowerPoint slides, as they are available on WebCT</td>
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<td>When I have a copy of the presentation beforehand, I find it easier for my mind to wander since I have already seen the material</td>
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<td>I find it boring when the lecturer says the same things the PowerPoint slides say</td>
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<td>I prefer slides that contain pictures, charts or graphs only</td>
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<td>I feel the lecturer should only give an outline of the lecture on the PowerPoint slides, as I would learn more in the lecture if I had to write some of the material</td>
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<tr>
<td>When I have a copy of the presentation, I am less likely to attend class since I already have the material</td>
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<td>I wish the lecturer would spend less time using PowerPoint slides</td>
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**General comments**

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