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Mechanical Engineering Education in Irish Context On route to becoming a Chartered Engineer

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Keywords: Bologna accord, Engineers Ireland, Programme Outcomes

Abstract

Engineering Education in Ireland and throughout Europe has changed dramatically over the last few years and the pace of change is ensuring that we, the educators are constantly keeping abreast of new developments and benchmarks. Programmes that were based on inputs from learners are now outcomes based and the onus is on the educators and facilitators to provide evidence that graduates are capable of conducting specific tasks, commonly termed as Programme Outcomes. Similarly, greater onus is now placed on the learner to take greater responsibility for their educational development. The new and current process of meeting the educational requirements of becoming a Chartered Engineer are been modified to meet new outcomes that are designed to enhance the engineering and professional development skills of the learner for 2013 and beyond. This paper discusses the development of Mechanical Engineering Programmes in Ireland, the associated programme outcomes and the alignment of engineering programmes in Europe. The paper will also discuss what the authors recognise as strengths and weaknesses within the engineering education provided now and in the future. These points are addressed under some of the following headings:

- Mechanical Engineering modular programme structure
- Outcomes based programme design
- Development of transferable skills
- Semesterisation of programme
- Becoming a Chartered Engineer

1.0 Introduction

The education of an engineering student has gone through dramatic changes over recent times, influenced by the Bologna Accord [1] and more recent European educational agreements. Many changes have taken place including programme duration, the skill set of the graduate engineer and the mobility of learners. Similar to the globalisation of trade, engineering education has seen similar developments whereby students can complete modules, semesters and years at a combination of institutes and graduating from their host institute with an accumulation of credits or more commonly known as ECTS's (European Credit Transfer System) [2]. For most European and Irish educational institutes, the most dramatic developments in recent years has been the shift from entry

standards to an outcomes based system. This system has been designed and defined to identify the necessary education, technical, applied physics and professional development of the engineering graduate to meet the educational standards to become a professional engineer or chartered engineer. The programme outcomes have been developed on a European and national basis to clearly identify the skill set that students should attain on exiting a programme in order to become a chartered engineer. In Ireland, the recognised body responsible for the engineering profession is the Institute of Engineers of Ireland (Engineers Ireland or EI) [3] and this Institute, through collaboration with European and worldwide bodies are responsible for assessing the quality and accreditation of engineering programmes. On graduation from accredited engineering programmes, graduates must complete a minimum of four years of relevant engineering work or studies in order to become a chartered engineer. In Ireland, an Honours Degree at NQAI (National Qualifications Authority of Ireland) [4] that is accredited by Engineers Ireland meets the educational standard for Chartered Engineering grade of membership. The NQAI system is shown in Figure 1. This type of programme can take a minimum of four years to complete and currently carries 240 ECTS's or 60 per year.

Those entering this programme from the second level educational system normally have a high level of mathematics and/or a science subject and have attained a prescribed number of points from their second level educational studies.
From the year 2013, the aim is to increase the educational standards from an Honours Degree to a Masters Degree in line with Bologna and other countries throughout Europe and the world. Currently the Honours Degree accredited programmes are recognised on a worldwide basic for meeting the educational standards of Chartered Engineer through the Washington Accord [5]. In the Irish context, education is currently free of charge for up to a period of four years. Students pay a registration fee each year and must support themselves and pay for books etc.
Some of the questions that need to be answered are based on the need for a master's qualification to become a chartered engineer, consisting of a minimum of five years of educational study;
How will programmes be designed to meet this?
Will it be supported by government?
Will it be a turn off for students?
Will it be a turn off for parents?
Will it result in negative publicity?
Will it upgrade the status of the engineer?
Will it undermine the economy that depends on a good supply of engineers?
Will it produce better engineers?
Will it have any effects either way?

2.0 Formation of a Chartered Engineer

Currently the formation of a chartered engineer takes a minimum of eight years and consists of two main phases;

1. The first phase consists of studying and successfully completing an engineering degree programme accredited by engineers Ireland as meeting the educational standards required for the title of Chartered Engineer
2. The second phase is called Initial Professional Development and involves the achievement of the competences necessary to apply engineering principles to the solution of engineering problems. This is further defined in the literature [5].

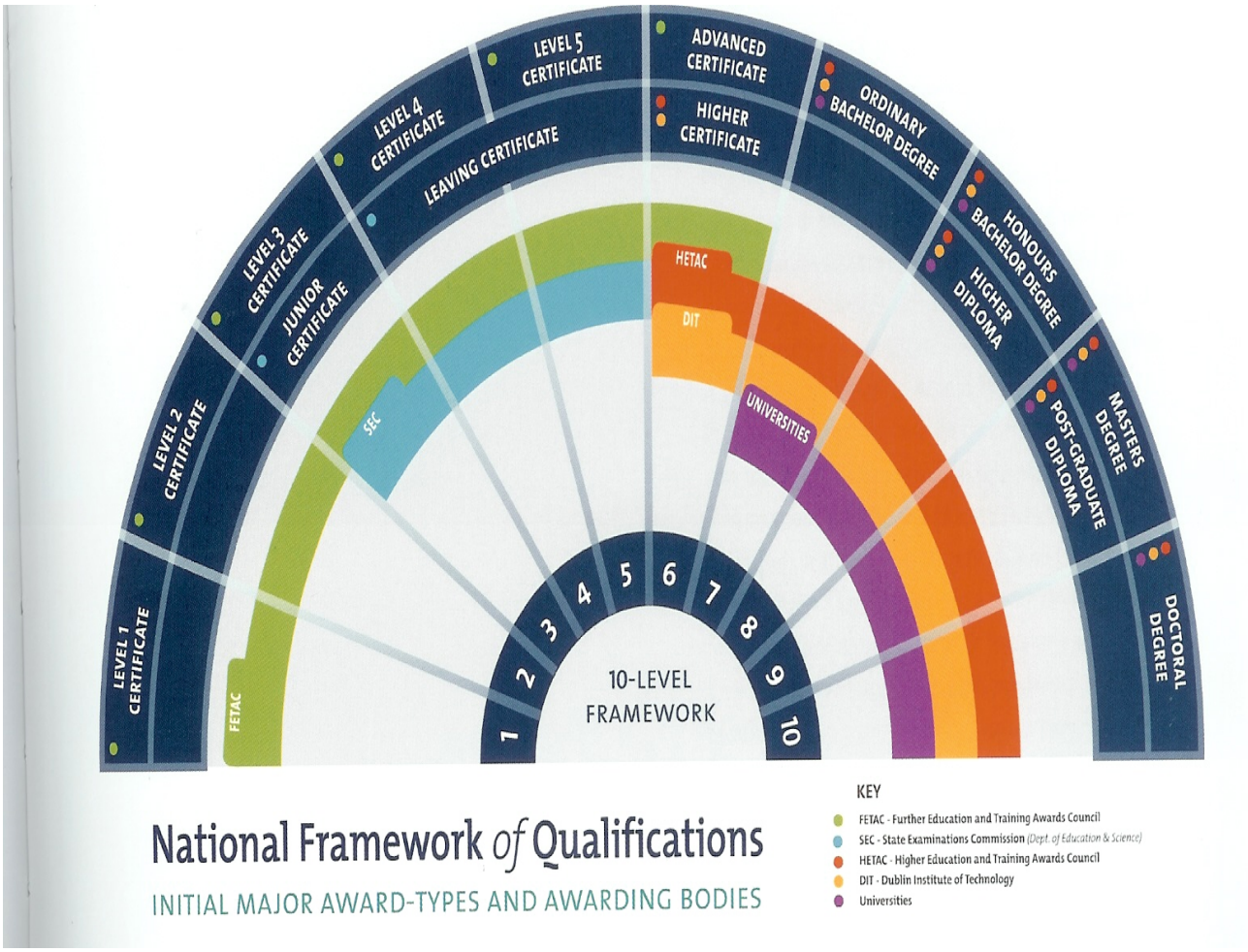

Figure 1. NQAI Framework of Educational Qualifications

2.1 Bologna Accord

The Bologna accord was established in June 1999 with the intention of establishing by 2010 a "European Higher Education Area," based on principles of academic independence and autonomy. The major goal was to produce a more transparent system whereby the different national systems would all be structured on three cycles: Bachelor, Master and Doctorate. The resulting Bologna Declaration has been central to educational reforms among all of the EU countries. The main signatories to this agreement are: Albania - Andorra - Armenia - Austria - Azerbaijan - Belgium - Bosnia and Herzegovina - Bulgaria - Croatia - Cyprus - Czech Republic - Denmark - Estonia - Finland - France - Georgia -Germany - Greece - Holy See - Hungary - Iceland - Ireland - Italy - Latvia - Lithuania - Luxembourg - Malta - Moldova - Netherlands - Norway - Poland - Portugal - The Former Yugoslav Republic of Macedonia - Romania - Russia - Serbia and Montenegro - Slovakia - Slovenia - Spain - Sweden - Switzerland - Turkey - UK – and Ukraine.

The Bologna Declaration aimed at ensuring that European higher education and research would be fully responsive to both social change and scientific advancement. To increase the competitiveness of European higher education, the signatories viewed these six improvements as essential;

Grades: Academic grades need to be easy to read and compare which would enhance international transparency. A system of comparable degrees emerged as a key improvement. A two-tier system-undergraduate and graduate-was adopted. The first cycle (bachelor's degree) was designed to last at least three years and the second cycle (master's degree) conditional upon the completion of the first cycle. The master's degree can lead to the third cycle, the doctorate degree. The signatories also agreed to establish a system for the easy transfer of academic credit through the European Credit Transfer System (ECTS), thus promoting student mobility, access and fostering European cooperation in assuring quality and compatibility. It also advocated the development of comparable criteria and methodologies for assuring comparable quality throughout European educational systems. These criteria and methodologies could be extended to other countries. A "European Dimension." In working toward a "European dimension of higher education," the signatories aimed at fostering a "convergence" of higher education systems by coordinating their programs of study, training and research.

2.2 Programme outcomes

The Programme Outcomes (PO’s) for meeting the educational standards for Chartered Engineer (CEng) are currently broken into six main outcomes as follows:

1. The ability to identify, formulate, analyze and solve engineering problems
2. The ability to design a system, component or process to meet specified needs, to design and conduct experiments and to analyse and interpret data
3. An understanding of the need for high ethical standards in the practice of engineering, including the responsibilities of the engineering profession towards people and the environment
4. The ability to work effectively as an individual, in teams and in multi-disciplinary settings together with the capacity to undertake lifelong learning
5. The ability to communicate effectively with the engineering community and with society at large

6. The ability to derive and apply solutions from a knowledge of science, engineering sciences, technology and mathematics

2.3 Programme Area Descriptors

Engineers Ireland has determined that the study of six programme areas is necessary if engineering graduates are to achieve the programme outcomes described. These are based on the following themes;

(a) Science and Mathematics
(b) Discipline specific Technology
(c) Information and Communications Technology
(d) Design and Development
(e) Engineering Practice
(f) Social and Business Context

Combining programme outcomes and programme areas results in a matrix as shown in Figure 2. The empty spaces can be filled with relevant learning outcomes from modules, subjects or courses that address these PO's and PA's

	Programme Outcome 1 Derive & Apply solutions	Programme Outcome 2 Solve Eng. Problems	Programme Outcome 3 Design, Experiment	Programme Outcome 4 Ethical Standards	Programme Outcome 5 Work in teams, etc	Programme Outcome 6 Communicate
Programme Area (a) Science & Maths						
Programme Area (b) Discipline Specific Technology						
Programme Area (c) Info & Communications						
Programme Area (d) Design & Development						
Programme Area (e) Engineering Practice						
Programme Area (f) Social & Business						

Figure 2. Programme Outcomes and Programme Areas

2.4 Learning Outcomes

Learning Outcomes are required for each module or element of a module

A learning Outcome is a statement of achievement which may take the form of the acquisition of:

1. Knowledge
2. Understanding
3. An Intellectual Skill
4. Practical Skill

They provide a clear explanation of what is required to complete successfully a module in a programme of study providing there are strong links between the learning outcomes, the assessment criteria and the assessment methods

1. Technical Skills
2. Transferable Skills
3. Work Related Attitudes
4. Development Goals

3.0 Mechanical Engineering Honours Degree Programme at DIT

The Mechanical Engineering Programme at Dublin Institute of Technology currently consists of four years or stage of study. This is divided into 8 semesters (two per year) with assessments during and examinations at the end of each semester.

The modules (subjects) for Stages 1 to 4 are shown in Figures 3 to 6 respectively.

Module Title	
Engineering Physics 1	Engineering Physics 2
Eng Applications & Introduction to Engineering	
Engineering Computing	
Engineering Chemistry 1	Engineering Chemistry 2
Mechanics 1	Mechanics 2
Engineering Drawing & CAD	Engineering Drawing (Building Services)
Engineering Drawing and Interpretation, Mechanical Machine Component / Assembly	Engineering Drawing (Structures)
Professional Development	
Engineering Mathematics 1	Engineering Mathematics 2

Figure 3. Stage 1 Modules for Mechanical Engineering

Module Title	
Control Engineering and Automation	Fluid Mechanics
Mechanical Engineering Design & CAD	Engineering Computing
Electrical & Electronic Engineering	Manufacturing Technology
Engineering Materials	Mechanics
Professional Development	Thermodynamics
Mathematics	Statistics

Figure 4. Stage 2 Modules

Module Title	
Applied Thermodynamics	Control Engineering
Engineering Management	Computer Modelling
Electrical & Electronic Engineering	Fluid Mechanics
Mechanical Engineering Design	
Mechanics of Machines	Mechanics of Materials
Engineering Mathematics	Engineering Materials

Figure 5. Stage 3 Modules

Module Title	
Computer Modelling	Control Engineering
Engineering Management	Fluid Mechanics
Energy Systems (Sustainable & Renewable)	Heat & Mass Transfer
Engineering Mathematics	Mechanics of Materials
Mechanics of Machines	Project

Figure 6. Stage 4 Modules

4.0 Assessment process

The Accreditation process is undertaken by a panel of three experienced experts, one of whom is normally from Industry. They receive the documentation form the Institutes/Universities or Colleges a few weeks prior to the visit and their report address the headings listed in Table 1. The visit of the panel to the relevant institute takes two whole days and their findings are presented to the institute where the programme resides prior to their departure. The outcome of the report may result in three results:

1. Full accreditation for the next five years
2. Three years accreditation if some deficits are found in the evidence presented to the panel.
3. No accreditation which can arise if there are major deficits or if the programme has never been accredited in the past

The report is then presented to Engineers Ireland where it goes before a committee responsible for programme accreditation.

ACCREDITATION PANEL REPORT
Department
Dates of Visit:
1. Programme Title:
2. Educational Standard being sought – Chartered Engineer
3. Programme Panel:
4. Compatibility with Engineers Ireland Guidelines
4.1 Entry Standard
4.2 Programme Duration and Structure
4.3 Resources including buildings, laboratories, equipment, academic and support staff
5. Analysis and Implementation of Programme Outcomes.
5.4 Programme Outcomes
Programme Outcome (a)
Programme Outcome (b)
Programme Outcome (c)
Programme Outcome (d)
Programme Outcome (e)
Programme Outcome (f)
6. Assessment of Student Performance
7. Student Transfer and Mobility
8. Features and Strengths of Programme
9. Recommendation to Accreditation Board
Conditions (mandatory) to apply to Accreditation
or
Deficits in Programme for which accreditation is not recommended
9.1 Recommendations (Non-mandatory) for Improvement of the Programme

Table 1. Accreditation Panel Report

5.0 Discussion and conclusions

From the outset, one noticeable feature of the programme outcomes is that three of them are dedicated to direct non engineering activities such as Ethics, Communication skills and working in multidisciplinary settings. The introduction of these outcomes indicate the importance such skills and attributes play in the working activities of a professional engineer. It is also fair to say that the last three programme outcomes are those that cause greatest difficulties to those running the programme and deficits normally derive from these. This shift to programme outcomes has created a change of approach for educational institutes and greater effort has been attributed to the personal development, teamwork, ethical and communication skills of an engineering syllabus.

For the future, the Bologna Accord is identifying a five year programme or Masters qualification as the educational standard for accreditation to Chartered Engineering awards. This may result in a 3+2 or 4+ 1 (Primary Degree plus Masters) configuration. It may allow greater collaboration with industry for student work placement during their educational training etc. However it is unlikely that adding extra years to a programme will result in government funding or free education for the whole five years. Decisions on this have yet to be agreed on. In conclusion, the programme outcomes approach has been welcomed by educational Institutes and has resulted in more creative ways of delivery of Honours Engineering Programmes in Engineering.

References

[1] Bologna Accord, 1999

[2] http://ec.europa.eu/education/programmes/socrates/ects

[3] Engineers Ireland Accreditation Criteria for Engineering Education Programmes, March 2007

[4] National Framework of Qualifications, A Framework for the development, recognition and award of qualifications in Ireland, Document number 2003/5, October 2003

[5] Chartered Engineer, Regulations for the title of Chartered Engineer, Engineers Ireland