THE FORMATION OF THE CHARTERED ENGINEER

William Grimson

Dublin Institute of Technology, Executive Member - Engineers Ireland.

email address: william.grimson@dit.ie

Abstract

This article sets out the standard for the formation of a Chartered Engineer in Ireland in terms of both the engineering education to be undertaken and the experience gained through employment following graduation. The educational standard is expressed in terms of learning outcomes and the experience gained in terms of expected and required competences: both the learning outcomes and competences as specified by Engineers Ireland are set out in detail. A brief account is also given of the application process and subsequent assessment and interview of candidates for the title of Chartered Engineer. Finally some comments are made on the challenges inherent in devising a curriculum that meets both the educational requirements and adequately prepares the graduate engineer to develop the full set of competences.

1. Introduction

The formation of an engineer is a process that is life-long and extends from early childhood play experiences to professional retirement and beyond. Put another way, the accumulation of knowledge of the world and how things work by an individual is not confined to a fixed period involving undergraduate education and immediate post-graduate experience. However, when it comes to adjudicating as to whether an individual can be considered a professional engineer, and in Ireland's case a Chartered Engineer, it is practical to consider the *formation* as being a period consisting of two approximately equal phases totalling a minimum of eight years, involving:

(a) education in an approved programme in an engineering college and

(b) relevant postgraduate 'work' experience

The main and twin features of the criteria by which a judgement is made as to whether an applicant can be considered to be a Chartered Engineer are:

1. achievement of learning outcomes programme and
2. competences attained through working in an engineering environment

In the case of Engineer's Ireland (EI) there is a formal accreditation process by which colleges submit their engineering programmes for review which if approved means that the graduates meet the educational standard of EI. An overview of what is involved is presented in the next section. Regarding the competencies expected of an engineer, programmes, involving nominally five years of study and attracting a minimum of 300 ECTS credits.

Programmes must enable graduates to demonstrate:

a) Knowledge and understanding of the mathematics, sciences, engineering sciences andtechnologies underpinning their branch of engineering.

Graduates should have, *inter alia*;

(i) knowledge and understanding of the principles, concepts, limitations and range of applicability of established mathematical tools and methods;

(ii) knowledge and understanding of the theoretical bases and the related assumptions underpinning the engineering sciences relevant to their engineering discipline;

(iii) knowledge and understanding of a wide range of engineering materials, processes and components;

(iv) knowledge and understanding of related developing technologies and how they might impinge upon their branch of engineering;

b) The ability to identify, formulate, analyse and solve engineering problems.

Graduates should, *inter alia*, be able to;

(i) integrate knowledge, handle complexity and formulate judgements with incomplete or limited information;

(ii) create models by deriving appropriate equations and by specifying boundary conditions and underlying assumptions and limitations;

(iii) identify and use appropriate mathematical methods for application to new and ill-defined engineering problems;

(iv) identify, classify and describe the performance of systems and components through the use of analytical methods and modelling techniques;

(v) develop software tools including numerical techniques to solve engineering problems.

c) The ability to design components, systems or processes to meet specific needs.

Graduates should have, *inter alia*;

(i) knowledge and understanding of design processes and techniques and the ability to apply them in unfamiliar situations;

(ii) ability to apply design methods to unfamiliar, ill-defined problems, possibly involving other disciplines;

f) The ability to work effectively as an individual, in teams and in multi-disciplinary settings, together with the capacity to undertake lifelong learning.

Graduates should have, *inter alia*;

(i) ability to recognise and make use of the interactions between the engineering technologies and the technologies associated with other disciplines and professions;

(ii) ability to consult and work with experts in various fields in the realisation of a product or system;

(iii) knowledge and understanding of the respective functions of technicians, technologists and engineers and how they together constitute the engineering team;

(iv) knowledge and understanding of group dynamics and ability to exercise leadership;

(v) ability to plan and carry through, self-directed Continuing Professional Development to improve their own knowledge and competence;

(vi) knowledge and understanding of concepts from a range of areas outside engineering.

g) The ability to communicate effectively with the engineering community and with society at large.

Graduates should be able to, *inter alia*;

(i) select and apply appropriate communication tools in order to create deeper understanding and maximum impact on a given audience;

(ii) describe succinctly, the relevant advantages and disadvantages of the various technologies to a lay audience;

(iii) communicate effectively in public, national and international contexts;

(iv) write technical papers and reports and synthesise their own work and that of others in abstracts and executive summaries;

(v) understand the training needs of others in appropriate engineering techniques.

Programme Area Descriptors

Engineers Ireland has determined that the study of six Programme Areas is necessary if graduates are to achieve the Programme Learning Outcomes. .The Programme Areas are:

(a) Sciences and Mathematics

(b) Discipline-specific Technology

decisions. The solution of engineering problems is facilitated by techniques such as structured information retrieval and filtering, simulation and quantitative analysis. Engineering students should therefore be taught the theory underlying those software and information systems which are of particular significance to engineering practice. The teaching of these topics will rely heavily on the students' knowledge of the relevant mathematical techniques. Students will also require instruction in the skills of using computers for the quantitative analysis, simulation, and solution of engineering problems. They should be shown how to apply, to adapt and, where necessary, through data exchange, to integrate industry–standard software tools and information systems. Software, information systems and the electronic encapsulation of knowledge play an important role in the manipulation and communication of engineering information. Students will therefore require skills in the use of software tools like word processors, presentation packages and spreadsheets for these purposes. They should be introduced to a wide range of computer-based data presentation techniques and should learn how to choose the most appropriate one for a particular set of circumstances.

(d) Creativity and Innovation

Research and design are central components of creativity and innovation. Research seeks to generate new knowledge which may lead, through the design process, to new products and systems. This Programme Area should facilitate students' understanding of the experimental method and how its application can lead to new knowledge and insights in an organised way. Students should be exposed to a range of standard and specialised research tools and techniques of inquiry and should have the opportunity to draw up and execute, independently, a research plan. Design is at the heart of engineering. Design studies should include consideration of the design process and of techniques specific to particular engineering products and processes. Students should be encouraged to think beyond the obvious and routine, and be given opportunities to face the challenges of previously unsolved problems. For example, consideration should be given to including in the programme, the art of problem solving, heuristics, TRIZ, etc. By these means, a student's ability to contribute to the creative process may be developed. Since engineering is ultimately about practical activities, such innovation should include the practical testing of ideas in the laboratory and conducting research for information to develop these further. These activities should be linked to technical analysis and the critical evaluation of results. Also related to practical issues, students should explore the various steps from idea to marketplace, including patents, business identifying their own learning needs and exercising responsibility for their own continuing professional development should be stressed.

3. Competences of a Chartered Engineer [1]

The standard expected of a professional, in the case of Ireland a Chartered Engineer, is articulated as a set of competences that the engineer should have developed and will in their future be obliged to maintain and extend [2]. Whilst the competences are necessarily generic the process by which they are judged in individual cases of applicants applying to become a Chartered Engineer rests strongly on the demonstration of how they have been gained and therefore relevance to a specific engineering sub-discipline arises naturally. The competences of a Chartered Engineer are listed and analysed in terms of the range of abilities normally associated with each one as follows.

<u>Competence 1</u>

Use a combination of general and specialist engineering knowledge and understanding to optimise the application of existing and emerging technology

This normally includes an ability to:

a) Maintain a sound theoretical approach in enabling the introduction of new and advancing technology and other relevant developments.

The Chartered Engineer:

1) Continually strives to extend capabilities by accessing and exploiting all relevant personal and professional development sources;

2) Exercises information retrieval skills to keep abreast of current and future technological or other relevant developments;

3) Broadens knowledge base through the Internet, the media, professional journals, attendance at professional seminars and networking;

4) Deepens knowledge base systematically through research and experimentation.

b) Apply a creative problem solving approach.

The Chartered Engineer:

1) Identifies and agrees customer, user and community requirements;

2) Exercises creativity and initiative in investigating, analyzing and conceptualizing possible solutions to achieve objectives;

[1] *Courtesy Engineering Council U.K.*

b) Conduct appropriate research, and undertake design and development of possible solutions.

The Chartered Engineer:

1) Demonstrates potential solutions by physical or computer models using mathematical analysis,computer simulations or other modelling techniques;

2) Analyses promising concepts for final design to assess impacts of factors such as performance,reliability and maintainability;

3) Undertakes cost-benefit and risk analyses, feasibility studies and life –cycle costing to produce a workable design;

4) Uses appropriate engineering and technological aids.

c) Plan and implement solutions, taking a holistic approach to cost, benefits, safety, reliability, appearance and environmental impact.

The Chartered Engineer:

1) Prepares and recommends for implementation a documented proposal to meet client or manufacturing requirements;

2) Prepares test schedules for performance and physical environmental testing, oversees testing, analyses test results and recommends or arranges tests;

3) Identifies possible problem areas and negotiates modifications or adaptations as necessary;

4) Takes corrective action to overcome any shortcomings revealed;

d) Evaluate the solutions and make improvements.

The Chartered Engineer:

1) Determines impact on design of factors such as production, construction, installations, commissioning, life cycle implications, logistic support and training of users;

2) Participates in consultation with affected parties on product or process evaluation;

3) Evaluates the solution against the specification;

4) Identifies potential improvements and ensures that they meet the specification, are practicable and are implemented;

<u>**Competence 3**</u>

Provide technical, commercial and managerial leadership.

This normally includes an ability to:

a) Plan for effective project implementation.

The Chartered Engineer:

Competence 4

Use effective communication and interpersonal skills.

This normally includes an ability to:

a) Work and communicate with others at all levels.

The Chartered Engineer:

1) Develops good personal relationships appropriate to the level of communication;

2) Communicates effectively in the English language and in other languages if circumstances dictate;

3) Takes part in discussions ensuring two way effective communication;

4) Responds effectively and efficiently to all received communication.

b) Effectively present and discuss ideas and plans.

The Chartered Engineer:

1) Clarifies objectives, identifies main purpose, and selects appropriate medium for communication;

2) Prepares and presents lectures and reports, and publishes papers at a professional level;

3) Selects appropriate methods of communication using words, images, audio and video, as appropriate;

4) Communicates fluently in written and oral expression at an experienced professional standard.

c) Build teams and negotiate.

The Chartered Engineer:

1) Identifies collective goals and responsibilities;

2) Works towards collective goals;

3) Creates, maintains and enhances effective working relationships:

4) Issues clear and accurate instructions to subordinates as appropriate;

5) Develops teams, individuals and self to enhance performance;

6) Undertakes negotiation, conflict resolution, counselling, exchanging ideas and conveying convictions and attitudes.

Competence 5

Make a personal commitment to abide by the appropriate code of professional conduct, recognising obligations to society, the profession and the environment.

In order to satisfy this commitment, Chartered Engineers must:

a) Comply with Codes and Rules and Conduct.

3) Prepares and maintains a career action plan;

4) Maintains records of professional development activities.

The above five competences have to be considered as a whole and deficiencies in any one area cannot be compensated by exceptional ability in another.

4. Process of application and interview

The applicant writes a Report the purpose of which is to provide a clear, comprehensive account of their career in terms of the following elements:

- Chronological details of career,
- Training Courses undertaken,
- Initial Professional Development (IPD),
- The name of the company / organisation providing employment,
- The title of the position held, and level of responsibility,
- The position, qualifications and / or membership of professional bodies of immediate superiors
- Two essays offering the candidate the opportunity to articulate opinions on important topics relevant to the professional practice of engineering.

Prior to making a submission each application has to be validated by two supporters of the applicant who are Chartered Engineers familiar with all or part of the career being examined. The report is subsequently assessed and if judged to be of the appropriate standard the application proceeds to the Professional Interview stage. The interview panel consists of three members of Engineers Ireland who are Chartered Engineers and who are considered competent by the Board of Examiners to make recommendations on the suitability of candidates for the title of Chartered Engineer.

The members of the Interview Panel are required to satisfy themselves that the candidate has attained an acceptable level in the competences based on the report and a one hour interview. Unsuccessful candidates are provided with the information regarding where they fall short of the standard. It is worth noting that there are a number of ways by which standards are maintained. All panel members receive training and experienced chairs are utilised who act as mentors for future chairs. Also on occasion visitors from professional bodies in other jurisdictions observe proceedings and provide useful feedback. This is an important exercise that underpins the various international agreements by which Irish engineers are recognised in various parts of the world.

References

[1] Accreditation of Programmes by Engineers Ireland: http://www.engineersireland.ie/services/programme-accreditaton/

[2] Competences required to be granted a title by Engineers Ireland http://www.engineersireland.ie/membership/become-a-member/apply-for-a-title/

[3] ENAEE/ EUR-ACE http://www.enaee.eu/

[4] ABET http://www.abet.org/

[5] Bucciarelli L, Coyle E, McGrath D. *Engineering Education in the US and the EU (pp105-127).* Engineering in Context (eds Christensen S, Delahousse B, Meganck M), Academica, 2009

[6] Grimson W, Dyrenfurth M, Murphy M. *Liberal Studies in Engineering and Technology.* Engineering in Context (eds Christensen S, Delahousse B, Meganck M), Academica , 2009

[7] Grimson W, Murphy M. *The Case for the Inclusion of a Lay Person or Persons on Engineering Accreditation Panels.* Abstract: 2010 Forum on Philosophy, Engineering & Technology. http://philengtech.org/wp-content/uploads/2010/05/fPET2010-abstracts-5-1-2010.pdf