Accreditation criteria as enablers

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INTRODUCTION

In the UK, the standards of competence and commitment that must be demonstrated to achieve professional registration as an engineer or technician are set by the regulatory body for the engineering profession, the Engineering Council [1]. Key to the development of competence is demonstration of the required underpinning knowledge and understanding, which for professional engineers is usually delivered via a university degree programme designed to meet the Engineering Council's standards. The requirements for accredited degrees are published in terms of learning outcomes.

During 2013, the Engineering Council undertook the periodic five year review of these degree accreditation criteria. This paper outlines: the review process; the thinking behind some of the revisions: the balance between avoiding whole-scale change to a standard that was broadly supported by stakeholders, whilst addressing matters that have come to the fore since the previous review; and, taking account of external drivers from the UK Government and others, the revisions related to skills and graduate employability.

Particular attention is paid to two key revisions: the integration of what are commonly termed ‘general learning outcomes' (which tend to underpin the employability or transferable skills that employers say they require) to be within the specific engineering/technical learning outcomes; and the clearer presentation of the distinctiveness between the four types of UK engineering degree. The UK accreditation framework is presented as an enabler for university engineering departments wishing to develop or update their degree programmes.

1 ENGINEERING DEGREES AND PROFESSIONAL FORMATION IN THE UK

1.1 UK engineering degrees

The most commonly offered UK first cycle engineering degrees are three year full-time (four years in Scotland) programmes leading to a Bachelors award with honours (BSc or BEng). Second cycle programmes include the MSc and the MEng degrees. While MSc degrees are discrete second cycle programmes, the MEng, termed an ‘integrated masters’ degree, combines both first and second cycle learning outcomes and is recognised as a second cycle qualification.

A range of other types of HE qualifications and provision is emerging including that combining academic study with workplace learning, and provision driven by industry’s needs. This may variously offer a route into higher education, such as the final year of a bachelors programme, or lead straight to a job. Such levels of employer engagement help to ensure that these programmes contribute strongly to enhancing an individual’s employability. Other emerging provision and the factors driving this are outlined in Shearman and Seddon [2] and a report by the Royal Academy of Engineering [3].

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1.2 Formation of a professional engineer

The professional status of engineers and engineering technicians in the UK is demonstrated by registration with the Engineering Council. Registration is based upon the demonstration of prescribed standards of professional competence and commitment, set out in the UK Standard for Professional Engineering Competence [4]. This generally involves a combination of formal education and further training and experience (known as initial professional development), and currently, most new Engineering Council registrants hold formal first or second cycle academic qualifications.

2 ACCREDITATION OF ENGINEERING DEGREES BY THE ENGINEERING COUNCIL

2.1 Process

Accreditation is a mark of assurance that the degree programme meets the standard set by the profession. The process starts with an application from a university. In the UK, accreditation by a professional body is not a statutory requirement, although most engineering degrees are professionally accredited. The required process is set by the Engineering Council and undertaken by discipline-specific professional engineering institutions that are licensed by the Engineering Council to do so [www.engc.org.uk/institutions]. It is essentially a process of peer review. Consistency and assurance of standards is achieved by the licensing arrangements which include periodic review of licences, and by the prescription about the process to be followed. This includes the constitution of visiting panels, the form of submission, and the range and type of evidence that must be considered. Further details are outlined in the Engineering Council's document 'The Accreditation of HE Programmes' (AHEP) [5].

This process of accreditation of programmes by the UK's engineering regulatory body is separate from quality assurance by the national agency, the Quality Assurance Agency for Higher Education (QAA) [6]. QAA operates at the institutional level rather than at programme level, checking how universities maintain their academic standards and quality.

2.2 Criteria for accreditation

Since 2003, the UK has operated an outcomes-focused basis for its engineering degree accreditation which has been broadly welcomed. The required output standards for each type of degree are set out by the Engineering Council [5] as learning outcomes and are derived from the competence and commitment requirements for professional registration [4]. The learning outcomes presented in AHEP cover broad areas of learning[2] and more general learning outcomes, sometimes known as 'transferable skills'. These are interpreted by the discipline-specific professional engineering institutions for their own area, and used by them to assess whether a degree programme provides its graduates with the required knowledge, understanding and skills for eventual registration as an Incorporated Engineer (IEng) or a Chartered Engineer (CEng). Aspects of QAA's quality code [7] are used such as its framework for HE qualifications. In an important development, since 2006 the QAA has adopted the standards in UK-SPEC as its national subject benchmark statement for engineering [8]. Approximately 2000 accredited engineering degrees are recorded on the Engineering Council's public searchable database www.engc.org.uk/courses

Fig. 1 Accredited course logos

English version: Engineering Council accredited degree

Welsh version: Engineering Council gradd achrededig

Degrees accredited since 2006 are also eligible for the award of the EUR-ACE® label.

[2] Underpinning science and maths; Engineering analysis; Design; Economic, legal, social, ethical and environmental context; Engineering practice.

Fig. 2 EUR-ACE® label logo

3 REVIEW OF THE ACCREDITATION CRITERIA

3.1 Process

The review undertaken by the Engineering Council during 2013 was overseen by a steering group drawn from the profession. The steering group members contributed a very wide range of accreditation experience whether from an academic, an industry or professional engineering staff perspective, and they represented a mix of engineering disciplines and size of institutions.

The process involved an initial desk review of the documentation and identification by the steering group of possible areas for consideration. This was followed by consultation via an on-line survey which sought views about areas for consideration and any more general comments about the document. Those consulted included employers and employer organisations, academics and professional organisations, to ensure that engineering degrees continue to equip graduates for employment in the 21st century. A period of drafting was followed by a second on-line survey to test the revisions. At each stage, the group's work was subject to scrutiny by the Engineering Council's Registration Standards Committee and its Board of Trustees, who had responsibility for final sign-off.

The holding of an accredited degree by itself cannot ever meet in full the requirements for UK professional engineer registration. Therefore the review of learning outcomes could not take place in isolation from the parallel review of the standards of competence and commitment for registration (UK-SPEC). Information flows between the steering groups for both documents were established. Dialogue with the Engineering Council's International Advisory Panel was essential to ensure alignment with Washington and Sydney Accords' graduate attributes [9] and with the EUR-ACE framework.

3.2 Areas considered during the review

After discussion, these were narrowed down to:

- the appropriateness for an international audience
- the link between learning outcomes and employability skills
- the differentiation between the learning outcomes for the four types of engineering degree
- presentational issues especially the desirability of publishing these as an absolute set for each degree, rather than as relative to a common (Bachelors Honours) reference set
- reviewing the extent of references to the following terms: understanding, knowledge, know-how, skills, awareness
- identifying topics which had come to the fore since the previous five year review
- identifying elements that might require strengthening such as design, systems approach, statistics, the societal context.

The first on-line survey revealed broad agreement with these and essentially indicated that the document was fundamentally sound. Of the respondents, 78% felt the language was clear and accessible (only 15% said 'no') and 66% felt the format and presentation was sufficiently clear (only 27% said 'no').

In relation to the Engineering Council's participation in international accords, the group was asked to consider developing a definition of 'complex' and to make explicit the expected level of problem-solving. Both of these have been addressed as part of the review, with the following definition of 'complex' adopted:

Complex implies engineering problems, artefacts or systems which involve dealing simultaneously with a sizable number of factors which interact and require deep understanding, including knowledge at the forefront of the discipline, to analyse or deal with.

In undertaking its drafting, the steering group was mindful of feedback that advised against proliferation of learning outcomes and design by committee, that stressed the need for outcomes to be brief but clear in content, transformable and transportable, and that the aim should be to simplify and consolidate rather than add and complicate.

4 REVISIONS TO THE ACCREDITATION CRITERIA

4.1 General and specific learning outcomes

The previous edition of AHEP included a fairly substantial list of general learning outcomes which were presented before the more technical learning outcomes and which were required of all graduates irrespective of their qualification level. When considering employability, the general learning outcomes for accredited engineering degrees appear to offer a particularly important basis for the future employability of undergraduates. These tend to underpin the employability or transferable skills that employers say they require. Shearman and Seddon [2] presented evidence to support this, by highlighting the close alignment between the Engineering Council's general learning outcomes and the Confederation of British Industry's employability skills for graduates.

Degree accreditation is dependent on demonstration of both types of learning outcomes, labelled general and specific. However rather than retain these as separate lists, the steering group proposed that there should be much greater integration of the general learning outcomes within the specific engineering/technical learning outcomes. This would have the advantage of the general learning outcomes not being seen as an 'extra' or add-on', it would strengthen their profile, and assist programme developers and programme accreditors. Examples of this integration include: integrating within the 'Design' area of learning the 'ability to communicate their work to technical and non-technical audiences'; and integrating references to team roles and personal responsibility within the 'Engineering Practice' area of learning.

This integration was relatively straightforward to achieve and only a few of the previously badged general learning outcomes proved difficult to incorporate. In the revised edition of AHEP these are presented as 'additional general skills' and form an additional (the sixth) area of learning for each of the four types of degree.

4.2 Differentiation between types of degree

As noted above, four different types of degree, at two different levels, may be accredited. The previous edition of AHEP presented the learning outcomes of one degree (Bachelors Honours) as the core or reference list, with the other three sets of learning presented in terms relative to this. The steering group proposed a different presentational approach which, although it would amount to some duplication, was felt to be much clearer and easier for all to use. The new edition includes the complete set of learning outcomes for each of four types of degree so that each is standalone.

This also enabled there to be more attention paid to the issue of the comparative levels of the degrees and made it easier to develop distinguishing 'preambles' for each degree. These preambles set out what each type of degree entails and the characteristics of its particular graduates. It is here where comparisons between knowledge and understanding can be stated. For example, the revised AHEP now clearly distinguishes between what graduates from accredited Bachelors (Honours) programmes and graduates from an accredited MEng degree must achieve in terms of how much of their knowledge is at, or informed by, the forefront of defined aspects of the relevant engineering discipline.

Two further revisions were the use of 'critically evaluate' to distinguish the higher cognitive skills expected of an MEng compared with a BEng (Hons) graduate; and for Masters degrees other than the Integrated MEng, some lists of examples have been replaced by 'in the context of the particular specialism', which recognises the specialist nature of many MScs and should be of assistance to those responsible for designing programmes.

The presentation of the four preambles as a comparative matrix for the purposes of the second consultation was so well received during the consultation that it has been retained as a comparative matrix forming a new Annex to AHEP.

4.3 Strengthening of topics and other elements

Since the previous review of AHEP in 2008, increased attention has been paid by the engineering profession and society in general to topics such as risk management, health and safety, ethics and intellectual property (IP), which in turn is reflected in what graduates are expected to know. During this time, the Engineering Council has published guidance for professional engineers and technicians on sustainability and risk. During 2013, the UK government's Intellectual Property Office embarked on a project to extend the coverage of IP in degree curricula across a range of disciplines. The 2013 review of the UK-SPEC led to the addition of one new standard of competence: 'exercise responsibilities in an ethical manner'.

The steering group was mindful in its work to keep a balanced view and not be unduly influenced by any particular lobby group during the consultation exercise. The revisions to topics have been kept to a minimum, with the following being strengthened: risk issues, health and safety, ethics, sustainability, the legal context and IP.

The following elements or approaches have been added or enhanced, variously prefixed with awareness, knowledge and/or understanding, depending on the type of degree:

- integrated or systems approach to problem solving
- statistical methods
- in relation to design: references to business and customer needs, wider considerations such as engineering context, and public perception in relation to design, and the ability to work with information that is incomplete or uncertain
- the addition of 'legal' and 'ethical' in the area of learning *Economic, legal, social, ethical and environmental* which despite making the title rather long, was felt to be a very important amendment

Feedback about the proposed revisions during the second on-line consultation was broadly very positive. Of particular note was that the vast majority of respondents felt that there had been no change to the Standard required for each degree, and that the proposed changes would not cause their institution any difficulty. The re-presentation of the document was welcomed. In response to feedback, the references to 'legal' were revised to ensure that these are not mis-interpreted as being more demanding than intended.

5 ENABLERS AND INNOVATIVE PROVISION

5.1 Engineering Council requirements

The list of prescribed learning outcomes in the revised AHEP remains brief. These are presented in six areas of learning which are sufficiently broad to accommodate the whole range of engineering disciplines:

- Science and mathematics
- Engineering analysis
- Design
- Economic, legal, social, ethical and environmental context
- Engineering Practice
- Additional general skills

The learning outcomes do not constitute a syllabus or curriculum, and being generic, they enable engineering departments to develop a range of provision.

When interpreted by the discipline-specific institution, the learning outcomes remain non-prescriptive regarding domain of application (e.g. petrochemical, food or water) and mode of delivery (e.g. via lectures, self-study, practical exercises or projects).

5.2 Advantages of the UK accreditation system

The 2003 shift to defining standards through learning outcomes has a central important advantage in that the mode of provision or how the outcomes are delivered is left to the programme provider. This provides engineering departments, where the expertise for provision resides, with a high degree of freedom to innovate and respond to emerging demands, for example from employers. This is explored further below.

The focus on outcomes and what graduates can do, rather than counting inputs such as hours or credits, ensures that graduates are better prepared and equipped for employment. It ensures that a more rounded consideration takes place, rather than a tick-box exercise, and a compartmentalised or linear approach to learning is avoided as a number of different learning outcome are likely to be delivered concurrently, through, for example, project work.

The 'devolution' of responsibility for undertaking the process of accreditation to licensed professional engineering institutions has several strong advantages:

- the Engineering Council's standards are interpreted for each specific technical discipline by experts in each discipline
- the professional engineering institutions have access to large numbers of experts
- it is an example of the important principle of separation of powers, namely legislature (here specifying the accreditation standards set by the Engineering Council) and executive (operation of the prescribed accreditation procedure)
- the licensed institutions can share good practice via a forum operated by the Engineering Council, the Engineering Accreditation Board (EAB) [10]
- and uniformity of standard is assured by the rigorous licensing procedure and the crucial importance of that licence to the professional engineering institutions.

The QAA's subject benchmark statements assist universities in describing their programmes, regardless of whether or not they are accredited. A benchmark statement is intended to be used as a reference point in the design, delivery and review of academic programmes. It does not represent a national curriculum nor does it prescribe set approaches to teaching, learning or assessment. It provides a picture of what graduates in a specific subject area might reasonably expect to know, do and understand at the end of their programme of study. The QAA's engineering benchmark statement uses the Engineering Council's requirements for accredited degrees (learning outcomes), and this alignment has been strongly supported by the academic community. It reduces the bureaucratic burden on universities and the clear involvement of the profession in defining the statement adds weight to the quality assurance process.

The focus on learning outcomes in the engineering academic accreditation process is advantageous to providers. The principal changes associated with new forms of degree programmes relate to inputs such as format, length of time for completion and involvement of employers. Therefore it would seem that existing accreditation processes should be applicable and of help to providers wishing to offer new types of programme, and this is happening, as shown by the examples given later.

In terms of the process for accreditation, sometimes a programme's novelty or its breadth may mean that it could be accredited by a number of professional engineering institutions. Joint accreditation visits can be organised under the auspices of the EAB which acts as a single point of contact, and for whom the Secretariat is the Engineering Council. EAB-organised visits are appropriate when accreditation is sought from a number of professional engineering institutions for either mixed discipline degrees or engineering courses with commonality. Much can be achieved by a sharing of practice or ideas. Accreditation is providing academics, as members of accreditation reviews, with the opportunity to look in-depth at how other universities do things, both in the UK and overseas, and hence bring the innovative ideas back to their home institution.

Sometimes, academics interpret the accreditation requirements more strictly than is intended, and it has been reported that some academics feel that the scope for manoeuvre is limited by these requirements [11]. Since then, much work has been done to engender a developmental relationship between engineering departments and the accrediting institutions, and to move away from viewing accreditation as a single one-off five yearly event. This may have contributed to the recent increase in innovative provision.

5.3 Examples of innovative provision

It has been suggested that with respect to innovation, accreditation has the advantage of challenging the sector to keep up to date, both in teaching approach and in subject awareness [12].

Innovative accredited provision was explored at two high profile events in 2013: the Engineering Professors Council Annual Congress and the Higher Education Academy's STEM Conference [13]. This showed that for those who wish, innovative provision can be accommodated within the framework of learning outcomes. Key to success is the development of a relationship with accrediting professional engineering institution(s) and discussions with them about the development of the degree programmes before they are offered. Innovative accredited provision may include a range of providers, the involvement of several departments, or a specific approach to industrial engagement or curriculum delivery. Examples of innovative provision can be categorised into the following broad categories:

- Multidisciplinary programmes
- Multi-site/consortia/international programmes
- Embedded professional development/registration and industry recognised qualifications
- Integrated work experience and embedded industrial projects
- Distance/online/intensive delivery mechanisms.

There are many examples of multi-disciplinary programmes, and the Engineering Council's framework for accreditation enables the accreditation of combined degrees (such as Environmental Engineering and Business Management, Engineering with a language). Discussions at the forum of accrediting institutions (EAB) revealed the general feeling that around two thirds of the total programme time would be required to deliver the required engineering outcomes. However, this is not a fixed requirement; whether a degree programme course holistically delivers the required engineering learning outcomes is still the ultimate criterion in awarding accreditation.

In some cases, such as where engineering is combined with architecture, the Engineering Council accredited degree is additionally accredited by the regulatory body for architecture, which provides extra flexibility for the graduates choosing their future professional registration options. A similar example is an accredited MSc in Applied Chemistry and Chemical Engineering where the requirements of the Royal Society of Chemistry are also met. An example where study extends beyond what might be termed 'academic', is an accredited Avionics Systems degree which includes a pilot studies programme where the student has the opportunity to learn to fly and build towards a pilot's licence.

The focus on the delivery of outcomes is well-illustrated by an example of an accredited degree in Materials Engineering. The university does not have a materials engineering department as such but this degree arose from a mechanical engineering degree and had sufficient materials engineering options and specialisms to enable its accreditation by the Institution of Materials, Minerals and Mining.

The number of degrees delivered by consortia or on multi-sites is increasing, and an outcomes-focused accreditation framework can embrace such developments. Often, these are excellent examples of industry involvement, adding value to the programme and to the graduate-readiness for employment in a particular sector. One example is an accredited MSc in Nuclear Science and Technology, a collaboration between eleven universities, which together represent more than 90% of the nuclear postgraduate teaching expertise in the UK's universities and research institutes.

A similar set-up is available for an MSc in Marine Technology involving six universities. In both cases, the graduates are highly regarded and sought after.

An outcomes-based approach provides universities with the flexibility to decide on factors such as the delivery mechanism, language of delivery, pedagogical approach (eg several UK engineering departments are using the Conceive, Design, Implement and Operate (CDIO) philosophy in their teaching) [14]. There are many other examples of accredited provision that has been enabled because of the Engineering Council's outcomes-focused approach, and a summary of case studies is available on the website [15].

However, issues remain, such as the need to dispel myths and mis-perceptions, some of which exist in the academic community and through corporate memory. These include reasons "not to change" the degree provision, and a lack of understanding of the accreditation standards, processes and their knock-on effects. However, the profession has already demonstrated by its accreditation of innovative programmes that accreditation is not the straitjacket some may believe it to be.

Further, the 2013 review of the Engineering Council's accreditation requirements has ensured that these are relevant and up-to-date, and therefore equip departments to meet the demand for graduates with the skills that industry requires. Demands from industry and perhaps students who are now faced with university tuition fees may require further development of innovative provision, and academics will find that the Engineering Council's revised criteria support this.

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