A professional competence approach to engineering formation, assessment and registration.

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Abstract: Professional recognition of engineers and engineering technicians in the UK is demonstrated by registration with the Engineering Council. It was formerly based on a series of defined inputs, but is now based upon the demonstration of professional competence and commitment, based on a multi-dimensional and holistic model of competence. Competence is generally achieved through a mixture of formal education and further training and experience, but these elements need not be separate and sequential and they need not be formally structured. There are three categories of professional and the registration structure is presented as a continuum, allowing for progression from one category to another.

The UK engineering profession and recognition as an engineering professional

The formation of professional engineers and engineering technicians in the United Kingdom, leading to the award of a professional title, has always been regarded as requiring more than the completion of formal education at the appropriate level. Evidence of further development through training and employment is also essential. The requirements were once stated in terms of inputs, and professional recognition was based principally upon successful completion of approved education, training and experience components. This approach was rooted in the expectation that, allowing for differences between sub-disciplines, the formation of engineers was a broadly homogeneous process. For example, a large proportion of graduate engineers progressed from higher education into training and development programmes in large organisations, and then to positions carrying a degree of responsibility which would within a certain period bring them to the level expected of a Chartered Engineer. Over the past two decades, widespread and rapid changes in the global business environment, together with political initiatives such as the privatisation of nationalised industries, have brought about many changes in business structures. As a result we now see more diverse employment and development patterns for engineers and technicians. These changes helped to reinforce a growing opinion within the engineering profession in the UK that assessment and recognition systems should be based upon the achievement of defined outcomes, rather than on inputs. As a result, professional recognition is now based on the demonstration of professional competence and commitment, as defined in the Engineering Council's United Kingdom Standard for Professional Engineering Competence (UK-SPEC), first published in 2003. [1]

The engineering profession in the United Kingdom is regulated by the Engineering Council through 36 professional engineering institutions (PEIs). These are licensed by the Engineering Council to assess their members against the UK-SPEC requirements, and to place those who can demonstrate the required competence and commitment on its Register of Engineers and Technicians. They may also be licensed to accredit engineering education programmes. The Register has four sections, and three of these are considered in this paper: Engineering Technician (EngTech), Incorporated Engineer (IEng), and Chartered Engineer (CEng). These titles (and the fourth title, ICT Technician) are protected by the Engineering Council's Royal Charter and may only be used by registrants. Achievement of registration in each category is to be valued in its own right, but lifelong learning and career development may also enable individuals to progress within the registration structure.

Under UK-SPEC professional registration is open to everyone who can demonstrate competence to perform professional work to the necessary standards, and the commitment to maintain their competence, work within professional codes, and participate actively within the profession. UK-SPEC describes the required competence and commitment in generic terms, to cover all sub-disciplines of engineering; each PEI has developed further documentation, explaining how these generic standards apply in the context of the sub-discipline or industry sector(s) with which it is concerned. The PEIs are also responsible for the assessment of applicants for professional registration; this involves consideration of a portfolio of documented evidence from the applicant's education and employment, which will show the range of engineering functions which the applicant has undertaken and the nature and levels of the responsibility which s/he has had to take when doing so. The assessment also involves the consideration of an extended essay and a *viva* examination (the Professional Review Interview or PRI) conducted by at least two experienced professional engineers. For those seeking to be registered as Engineering Technicians, the assessment may be on the basis of documentary evidence only. The final decision on whether to register an individual is made by the responsible committee of the PEI, which will consider the recommendation made by the reviewers.

The PEIs' assessment processes and other procedures are quality assured through the Engineering Council's licensing system. PEIs are licensed for five years at a time and renewal of licences is dependent upon the Engineering Council remaining satisfied that procedures are adequate and that the UK-SPEC standard is not being compromised. The quality assurance system is based on peer review and is operated through a pool of volunteers from all the PEIs. While the system is based on assuring processes, the observation of Professional Review Interviews by volunteers from other PEIs provides an element of informal moderation of assessments.

The nature of professional competence

The word competence has been used extensively in the USA, UK and Europe over the past two decades or more in a variety of contexts, in relation to both organisations and individuals. It has acquired a range of meanings; these have varied according, for example, to whether it is being used in the context of human resources strategic management, or that of professional education and development. The meaning has also varied according to national and cultural context.[2] In the UK, competence was associated in the late 1980s and 1990s with an approach based on functional analysis of occupational roles and the skills needed to perform them, and this approach underpinned the development of National Vocational Qualifications (NVQ), often for very specific occupational roles. In engineering, these were predominantly operative or craft roles which would not be undertaken by professionals. This concept of competence was criticised for, amongst other things, appearing to downplay the place of knowledge, understanding, and professional values, and was certainly unsuitable as a basis for a system of professional standards and recognition.

A broader approach is taken in UK-SPEC, which says that "*Professional competence integrates knowledge, understanding, skills and values. It goes beyond the ability to perform specific tasks*." This approach seeks to capture underlying knowledge and behaviour, and not simply functional competences associated with specific occupations. It has much in common with holistic models developed in the UK in the past decade.[3] Professional competence encompasses:

- Cognitive competence, including underlying theory and concepts, as well as informal tacit knowledge gained experientially;

- Functional competence (skills and know-how);
- Personal competence (knowing how to behave);
- Ethical competence (possession of appropriate personal and professional values and the ability to make sound judgements based on these);
- Meta-competence (the ability to deal with uncertainty, learning, and reflection)

This multi-dimensional model of competence may be thought of as comparable with the holistic approaches to competence taken in France and Germany, incorporating for example the French concepts of *savoir* (or *connaissance*), *savoir-faire*, and *savoir-être.*

The UK-SPEC competence framework and the categories of engineering professional

The professional engineering community in the UK, as defined by those registered with the Engineering Council, has three different categories, Engineering Technicians, Incorporated Engineers and Chartered Engineers. The competence and commitment requirements for each of these are of course different and reflect the differing levels of technical knowledge and expertise and of technical and managerial responsibility which define each group. However the three sets of requirements can be seen to fit within a common framework and in particular the standard for all three categories reflects the need for all engineering professionals to demonstrate a personal and professional commitment to society, their profession, and to the environment. Moreover the possibility of progression between different registration categories is now explicitly acknowledged, although registration in each category is still regarded as valuable in its own right. This is in contrast to previous standards, which not only presented the three categories as hierarchical rather than progressive but downplayed the concept of movement between them. Acknowledging the possibility of progression does not mean that progression will be universal or even common. Individuals wishing to move from one registration category to another will be subject to searching assessments, and will only be able to do so if they can demonstrate that they have developed their professional competence to a higher level. However it does reflect the fact that we live in an age of lifelong learning. Employers have a strong interest in developing the competence of their employees, and in some areas of engineering employment there are clear career development pathways which will facilitate progression. It also reflects the fact that the kind of competence which is described in

UK-SPEC is developed throughout life, often through tacit and informal learning as well as through structured programmes.

Each category of registrant has a descriptor of which the key elements are as follows:
Engineering Technicians – are concerned with applying proven techniques and procedures to the solution of practical engineering problems, and carry supervisory or technical responsibility;
Incorporated Engineers – maintain and manage applications of current and developing technology and are engaged in technical and commercial management;
Chartered Engineers – develop appropriate solutions to engineering problems, using new and existing technologies, through innovation, creativity and change, and are engaged in technical and commercial leadership.

These descriptors provide a basis for the development of professional competence standards for each professional category. These are set out in a common format and under five broad headings. Two of these cover technical engineering competence, and the three others cover respectively responsibility, including management and leadership, interpersonal skills and communication, and the commitment to behave in a professional manner, recognising obligations to society. The framework is set out in figure 1.

	Engineering Technician	**Incorporated Engineer**	**Chartered Engineer**
A	Use engineering knowledge and understanding to apply technical and practical skills	Use a combination of general and specialist engineering knowledge and understanding to apply existing and emerging technology	Use a combination of general and specialist engineering knowledge and understanding to optimise the application of existing and emerging technology
B	Contribute to the design, development, manufacture, construction, commissioning, operation or maintenance of products, equipment, processes, systems or services	Apply appropriate theoretical and practical methods to design, develop, manufacture, construct, commission, operate, maintain, decommission and recycle engineering processes, systems, services and products	Apply appropriate theoretical and practical methods to the analysis and solution of engineering problems
C	Accept and exercise personal responsibility	Provide technical and commercial management	Provide technical and commercial leadership
D	Use effective communication and interpersonal skills	Demonstrate effective interpersonal skills	Demonstrate effective interpersonal skills
E	Make a personal commitment to an appropriate code of professional conduct, recognising obligations to society, the profession and the environment	Demonstrate a personal commitment to professional standards, recognising obligations to society, the profession and the environment	Demonstrate a personal commitment to professional standards, recognising obligations to society, the profession and the environment

Figure 1: The UK-SPEC competence framework

Each of these headline statements is developed in more specific sub-statements in UK-SPEC and the reader is referred to that publication for the detail. Even so, the UK-SPEC competence standards, especially the A and B statements which deal with technical competence, remain at a fairly high level of generality, because they apply across all sub-disciplines of engineering. It is the role of the individual PEIs to offer guidance on what might be looked for in the context of each sub-discipline.

One of the most discussed aspects of the UK-SPEC framework is the relationship – and the differences – between the different categories of engineering professional. While a clear distinction can easily be seen between Engineering Technicians and the two categories of professional engineer, the differences between Incorporated Engineers and Chartered Engineers have been much debated. The position of Incorporated Engineers within the registration framework was reviewed in 2007/8 and the competence standards for them and for Chartered Engineers were revised in some places in order to clarify the distinction between them. The standard now presents them as two different points on a continuum, rather than as two completely different types of engineer. In earlier professional standards the work of a CEng was referred to as "*predominantly intellectual and varied*" while that of an IEng demanded "*a practical approach and a detailed understanding of a particular technology*." A second distinction which has been made is to describe CEng as concerned with the development and application of new technologies and advanced designs, techniques and concepts, while IEng are concerned with the management, maintenance and application of current technologies and processes. Neither of these distinctions is now regarded as entirely accurate, and the distinction is now seen as one of different levels of autonomy and responsibility, and complexity of issues dealt with. Thus for example both categories may have an involvement with theoretical and applied research, but the Chartered Engineer's role in this will be a leading one, while the Incorporated Engineer will have a contributory role. Both may be involved with design and development, but the Chartered Engineer's role is likely to be at a more strategic and conceptual level. On the other hand, the Chartered Engineer as well as the Incorporated Engineer may be concerned with existing technologies as well as developing ones.

Competence, knowledge and understanding, and education

There is an essential cognitive dimension to professional competence, and this is generally referred to in UK-SPEC as *knowledge and understanding*. It is inherent in the notion of competence that this can be acquired through a variety of formal and informal means. However, formal education culminating in the award of a degree, diploma or other certification is the normal way of acquiring and demonstrating it, and UK-SPEC specifies certain degrees and other awards which exemplify the knowledge and understanding required for different categories of professional recognition. These are:

Engineering Technicians - a range of awards at level 3 or above in the national Qualifications and Credit Framework, approved by PEIs in accordance with rules set out by the Engineering Council;
Incorporated Engineers – an accredited Bachelors (first cycle) degree;
Chartered Engineers – **either** an accredited Bachelors (first cycle) degree plus an accredited Masters (second cycle) degree, **or** an accredited integrated Masters (MEng) degree.

The accreditation of engineering degrees, whether at first or second cycle, is undertaken by the PEIs in accordance with regulations set out by the Engineering Council.[4] Since 2004 the accreditation system has been outcome-based, and the sole criterion for accrediting a programme is that it delivers the required learning outcomes at the appropriate level (first or second cycle). Process issues such as delivery mode are indicators rather than absolute criteria. The Engineering Council has developed a framework of required learning outcomes which covers all accredited Bachelors and Masters degrees. This outcomes-based approach has been incorporated into various international agreements, including the EURACE framework maintained by the European Network for the Accreditation of Engineering Education (ENAEE). A small proportion of Bachelors degrees is accredited only to deliver the knowledge and understanding dimension of Incorporated Engineer competence, but the great majority of Bachelors degrees are accredited to meet both the Incorporated Engineer requirements and, when supplemented by an accredited Masters degree, the Chartered Engineer requirements as well.

In recent years, just over 70% of those gaining registration with the Engineering Council have held the exemplifying qualifications for their category of registration. For those would-be registrants who do not hold these, there is a range of other ways of assessing knowledge and understanding. For some, this may be through assessing the degrees or other certification which they hold and judging that these provide adequate evidence of the required knowledge and understanding. For others, it may be through an assessment not only of certificated learning but also of experiential learning. This will generally require the individual to present a technical report or a reflective statement which demonstrates how they have developed the knowledge and understanding at the appropriate level, and references this against the UK-SPEC

required learning outcome statements. Assessment of this may take place at the same time as the other elements of professional competence are assessed. This is not a trivial exercise for either the individual concerned or the assessors, but it is consistent with the philosophy behind UK-SPEC that professional registration should be available to everyone who can demonstrate the required competence and commitment, and with the progressive model of registration.

Developing full professional competence

Clearly formal educational programmes, as well as developing the cognitive dimension of competence, can also help to provide some of the other dimensions as well. It is a requirement under UK-SPEC that all accredited degrees, as well as delivering specific learning outcomes related to the sub-discipline of engineering, should equip their graduates with general outcomes of knowledge and understanding, intellectual abilities, practical skills and general transferable skills – concepts which accord very well with some of the different dimensions of professional competence which have been listed above. However, these aspects of competence will be developed to their fullest extent in employment. Although patterns of graduate employment are more varied than once was the case, many larger employers still run well-established training and development schemes for graduate engineers and these usually take specific account of the UK-SPEC competence requirements and are accredited by the PEIs on that basis. Other employers, particularly smaller ones, may not have schemes of this type. Engineers in these companies will need to develop profiles of competence and professional activity to help them prepare for registration. Even without a formal training scheme employers may use competence frameworks for staff development, and these should assist in developing a competence profile. The PEIs will always offer advice and guidance about this as well as facilitating mentoring. A number are also now using on-line systems to assist individuals in recording evidence of competence development.

While education, training and employment were once presented as distinct and sequential phases, UK-SPEC recognises that elements of them can take place at the same time and be integrated. The most obvious example of this is in relation to Engineering Technicians; in many sectors, an approved Advanced Apprenticeship programme offered by an employer will involve educational programmes providing

certificated learning at the appropriate level, and occupational training in the work place leading to certificated functional competence, all taking place while the apprentice is in full-time employment. This integrated package will take apprentices very close to being able to demonstrate full professional competence as an Engineering Technician. There is some interest in extending the apprenticeship model to higher levels, which might offer a pathway to registration as an Incorporated Engineer.

For would-be Incorporated Engineers and Chartered Engineers, there are also opportunities to integrate the different elements, for example through industrial placements during degree courses. Particular scope for integration may exist for those with Bachelor's degrees who aspire to become Chartered Engineers and need to demonstrate knowledge and understanding to Masters level. A number of Masters degrees are offered through part-time study, but there are other possibilities.

Since 2006, the Engineering Council has worked with a number of universities and PEIs to develop an integrated model of provision, where the work-based development of Masters level knowledge and understanding and the development of the skills and competence required for CEng status are integrated in a flexible second cycle degree (MSc Professional Engineering). This is being offered as a pathway to professional qualification by five UK universities, and other universities are at various stages of programme development. The first graduates are expected in 2011.

Responsibility for the assessment of an individual's progress is shared: an academic supervisor assesses whether the individual has achieved the masters level knowledge and understanding, whilst a mentor provides support and guidance on the demonstration of competence. Such models require there to be carefully defined roles and responsibilities and close collaboration between the various stakeholders, especially at the beginning during the initial exercises to map an individual's competence against the required standard.

Whilst the academic content and relevance of the programme is critical to all stakeholders, the quality assurance and administrative infrastructure have proved to be equally important, since the development of documentation that would be acceptable to a range of professional and academic organisations and enable professional

accreditation at some point in the future is pivotal for the overall success of the programme.

The pathway is supported by twelve of the UK's professional engineering institutions. A first evaluation has shown that this approach is meeting a need amongst some particular target groups.[5]

Conclusion

The development of a system of professional registration based upon the demonstration of professional competence and commitment has been endorsed by the UK engineering profession and supported by employers of engineers. Considerable interest has been shown in it by other professions. It has the great advantage of being adaptable to changing circumstances and is not dependent upon particular patterns of employment, education and professional development. Those who follow one of the exemplifying academic pathways will find the process more straightforward than those who do not, and this provides universities and others with the incentive to develop programmes which meet the criteria for professional accreditation. However those who follow other paths are not debarred from gaining professional recognition. The system does require rigorous and transparent assessment processes, and presents the profession with the challenge of maintaining a large pool of competent and up to date assessors, who provide their services on a voluntary basis. There will be further challenges to be faced; in particular dealing with the effect of forthcoming major changes in the funding of higher education, which may affect individuals' choices. However, there is every reason to believe that the system is robust enough to cope with these and to continue to thrive.

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