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Abstract	This chapter focuses on the quality assurance (QA) of higher engineering education in the United Kingdom and Europe, by considering eight challenges which are predicted by the writer to be of increasing importance in the years ahead. QA in higher education is taken here as a process that sets out to assure society, and responsible bodies within it, about the quality of educational provision for students. The purpose of the chapter is to identify the present and forthcoming challenges and changes in QA in engineering education in the United Kingdom and Europe, in the light of present circumstances as well as of the historical context**.**

Quality Assurance in European Engineering Education: Present and Future Challenges

John Cowan

Abstract This chapter focuses on the quality assurance (QA) of higher engineering education in UK and Europe, by considering eight challenges which are predicted by the writer to be of increasing importance in the years ahead. QA in higher education is taken here as a process that sets out to assure society, and responsible bodies within it, about the quality of educational provision for students. The purpose of the chapter is to identify the present and forthcoming challenges and changes in QA in engineering education in UK and Europe, in the light of present circumstances as well as of the historical context.

Introduction

There are many challenges which will become increasingly important in the years ahead for those in engineering education in Europe. This chapter is organised around the following topics, for each of which is advanced a constructive suggestion for action or a prediction of forthcoming change. All of these topics involve significant challenges as follows:

1. Responding in our quality assurance (QA) to political decisions seeking a unified European approach to higher education.
2. Developing the rigour of the practice of QA in engineering education.
3. Confronting the long-established practice of concentrating on relatively lower-level outcomes and aims in much of engineering education.
4. Finding effective ways to develop higher-level abilities, both cognitive and interpersonal, and evaluate how well that is being done.
5. Arranging QA to cope with the sometimes conflicting demands of professional bodies and educational authorities.

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6. Ensuring that the oversight of quality is informed, independent and objective.
7. Enabling change in some of the outmoded, but enduring, teaching practices of yesteryear.
8. Extending our QA to cover self-managed and self-directed continuing professional development (CPD).

While readers in North America and elsewhere will no doubt see striking contrasts between values, practices and trends on both sides of the Atlantic (Heywood 2005), many of the above topics relate equally to education and accreditation in other nations and professional areas. This certainly applies within Europe, as the amplification of Challenge 1 should make clear.

In considering the QA of higher engineering education, it is important to distinguish between academic awards that testify to a certain level and scope of learning and development on the part of an individual, and what is called their professional accreditation, which entitles the accredited person to practise professionally. The author will follow the predominant (but not consistent) UK usage and take assessment (Heywood 2000) to be a process in which judgements of a student's ability or understanding are made, in contrast to evaluation (Calder 1994), which is a process in which judgements are made of the standard and quality of an academic programme, or a component of it. QA is therefore an evaluative process in which consideration is given, inter alia, to the validity, reliability, relevance and standard of embedded processes of assessment.

Challenge 1: Bologna and Thereafter

In 1999 the European Community agreed, and declared in the Bologna Declaration (European Higher Education Area 1999), that in order to promote the European system of higher education world-wide, European countries would:

- Adopt a system of easily readable and comparable degrees to promote European citizens' employability and the international competitiveness of the European higher education system.
- Adopt a system essentially based on two main cycles: undergraduate and graduate.
- Establish a system of credits (European Commission 2005) – such as in the European Credit Transfer system (ECTS) – to promote widespread student mobility.
- Promote that mobility by overcoming obstacles to the effective exercise of free movement of students, teachers, researchers and administrative staff.
- Promote European co-operation in QA, with a view to developing comparable criteria and methodologies.
- Promote the necessary European dimensions in higher education, particularly with regard to curricular development, inter-institutional co-operation, mobility schemes and integrated programmes of study, training and research.

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Note that in all of the above items, general conformity across the board, and in all discipline areas, is clearly assumed. There are unlikely to be any exclusion for either a discipline or a country. Notice also though that the difference between the rhetoric of much QA procedures as documented, and reality as QA is presently practised, can be stark.

It is, of course, the penultimate bullet point which is of particular importance in the present context. The key word, perhaps, is comparable – which does not necessarily mean identical. I foresee tension between those countries in which, at present, detailed syllabi and precise standards are determined by ministries of education, and those in which the sector is virtually self-regulating, while being accountable, somehow, for its management of quality. I would expect those in the latter group to co-operate nationally and internationally as suggested, at least in the interim stages, and to do so overtly or covertly. They will strive for various reasons to bring their present systems for QA reasonably into line. However, the former group may well resist the imposition of many such standards and methodologies, because they will call for overmuch change, or will not receive ministerial approval. In addition, the professional bodies in some countries will also contribute part of the resistance to change, through fear of losing their *power* to determine the nature of the degrees which they accredit.

Challenge 2: Ensuring Adequate Rigour in Quality Assurance

As an engineering academic for the last 45 years, I have had extensive and recent experience as an external examiner in the UK system (Lewis 2005) on various engineering degrees, as an international educational consultant and as an auditor/reviewer for the UK Quality Assurance Agency (Hodgson 2005). Sadly, this experience suggests that the rigour of QA in European engineering education has compared unfavourably in the past four decades with that which could be found contemporaneously in at least some other discipline areas. There is much work to be done to bring engineering in line with best practice. We need to catch up; and thereafter to progress, as some others are even now doing.

QA procedures in the more progressive educational institutions now routinely depend upon the following features of the programmes whose quality is being assured:

- Comprehensive specifications for modules or other elements of programmes (QAA 2008).
- Full alignment (Biggs 2003; Cowan 2004a) between intended learning outcomes, methods of assessment and the learning and teaching activities.
- Regular self-evaluations of programmes.
- Annual reviews of these self-evaluations by internal colleagues, drawn from outwith the programme team.
- Formal validations before first delivery of a programme, and subsequently at perhaps 5-year intervals, by panels which include external experts.
- Use of data covering both student learning and their learning experience.

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- Students' involvement in the undertaking of reviews and reports.

Increasingly, in the more advanced institutions, the end result of their internal processes of review is an objective self-evaluation, formulated against declared criteria and using recognised sources of data. When these are available, it only remains for an external QA process to audit, which properly then entails confirming the adequacy and accuracy of all the elements of the internal evaluation which is placed before it – including the final internal judgement.

Such schemes for QA represent best current practice. They have only emerged and developed gradually in recent years. They are by no means the norm at the time of writing, even in the more advanced European countries. But they occur sufficiently frequently to demonstrate that the above features are feasible, and are of benefit (eventually, perhaps) to the institution and to the country. Consequently they will increasingly encourage those in authority elsewhere to expect, if not demand, such activity of their staff.

Challenge 3: Level of Expected Outcomes

Forty years ago, much of engineering education, if judged by its examinations and coursework, concentrated upon the assimilation, understanding and recall of basic knowledge, together with the application of routine algorithms or methods to carry out somewhat predictable calculations (Cowan 2006a). The higher-level abilities of analysis, creativity and synthesis, and the making of judgements, seemed to be expected to develop by osmosis (Bowden 2004). Interpersonal skills, which figure so highly in our professional lives, were often not touched developmentally in formal curricula (Cowan 2004b).

Nowadays, the situation has changed radically. In professional practice, the routine knowledge which engineers require can usually be retrieved in a suitable form through the simple use of a search engine. Explanations, if needed, can be similarly accessed, and need only be mastered when they are needed. Routine applications are readily undertaken on our behalves by commercial software (Cowan 2006b). Yet it is my experience, particularly as an external examiner and auditor that many of the demands in current day engineering assessments are still at a regrettably low and inappropriate level. They are thus often redundant in terms of usefulness in employment after graduation.[1]

[1] A former student of mine, who has had extensive experience in engineering education and is now a well-regarded member of senior academic management, kindly read an earlier draft of this paper and commented (Matthew 2008) in support of this point that:

> From my experience of engineering education, your challenges 3, 4 & 5 are the key ones – and there seems to be a real conflict here between what the professional bodies say in accreditation literature and the reality of what they look for on accreditation visits to university departments. My experience leads me to think there is still an undue emphasis on the low level, easy to measure abilities and skills and little pressure put on university departments to radically change the curricula and the pedagogy to really deliver the kind of engineers that the professional bodies profess to want.

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QA and external examining procedures in universities have become increasingly aware of this weakness, and are calling for attention to be given to it. In particular we urgently need, as a profession, to align our assessed demands, the so-called hidden curriculum (Snyder 1971), with the requirements of the profession and the expectations of employers. That need is easily stated than achieved. However, failure to deal with it may prove a stick for our backs. For the management of QA increasingly adopts a cross-disciplinary approach and many powerful personalities nowadays wish to ensure comparable levels of demand across disciplines and their awards. This trend, which naturally leads to comparisons and consequent criticisms, is particularly apparent in European discussions and negotiations subsequent to the Bologna Agreement, as nations have sought to face up to its implications (see Challenge 1).

Challenge 4: Developing, Assessing and Evaluating Higher-Level Abilities

When I began to teach structural engineering in 1964, it was easy to confirm that a student understood a concept; we could simply ask them to explain it. It was relatively straightforward to teach towards that understanding. We could explain, and give examples, until the concept had been grasped. It was equally straightforward, having assessed the student's grasp of that concept, to then assess their ability to apply that understanding, in particular examples.

It is considerably more difficult to bring about achievement of today's higher-level educational demands. In our teaching nowadays we should be developing in students their ability to generate creative solutions in problem solving (Cowan 2006c). We should also be developing their ability to expand their original plans in detail, and then to judge the merit of these solutions, comparatively and objectively. These are demanding pedagogical challenges. They call on us to create and deliver effective learning and teaching activities and to have confidence in their outcomes. It is yet more demanding to work out how to assess the development of these abilities in our examinations and assignments. And it is even more difficult, for those who are responsible for QA, to make and confirm judgements on the effectiveness of such learning and teaching activities and on the alignment of the assessment instruments. In European practice generally, this is an important challenge with which little progress has been made at the time of writing, and even that merely in pockets of specialised activity.

It seems likely that developments in QA will depend upon the involvement of students as colleagues in programme evaluation and QA (Brooker and Macdonald 1999). They can assist, for a start, in determining what development of abilities has actually taken place (Campbell et al. 2007). This would be especially true of the involvement of recent former students, now in the market place, and who have gained a reflective perspective into the curriculum, For example, it is often only the learners themselves who know, and can claim objectively, the true extent of their creativity (Cowan 2006c). Already in some jurisdictions, including my own country

of Scotland, we are seeing the active involvement and integration of trained students in QA procedures. These scrutinise the effectiveness and standard of provision (Gordon 2002), whose outcomes feature inter alia higher-level learning and development – and focus in addition on enhancement-led review. There appears considerable potential in this latter development in matters of quality, although already there is perhaps an increasing danger (Matthew 2008) in that some people want to quality assure quality enhancements, rather than systematically evaluate their impact on the student experience.

Challenge 5: Integrating Conflicting Demands

Traditionally, professional bodies (Maillardet 2004) have (rightly and understandably) concentrated upon ensuring that graduates have the necessary grasp of disciplinary fundamentals (Heywood 2005), together with proven competence in essential professional skills – before they seek licence to practice. Graduates should then progress to accreditation and professional status, by demonstrating that they have had suitable practical experience and have developed necessary practical competences (Becher 1999).

Until recently, educational institutions have found little difficulty in responding to these expectations of their role in the first stage of this process. They have internally validated their programmes, and confidently exposed them to a second stage in which these programmes are accepted by the relevant professional body or bodies, or even, in some countries, by government ministries.

Recently, however, problems have troubled this arrangement. These have arisen because:

- Developments based on information technology have removed many lower-level skills from curricula (see Challenge 4). Many of the basic engineering skills are now economically and more effectively delivered by the new technology. In their place employers therefore rightly look for employable graduates to offer higher-level cognitive, interpersonal and social skills (Beder 1999). These are generic rather than disciplinary, and should apply and be developed across our curricula.
- As already mentioned, the subject matter of engineering courses has an increasingly short shelf-life. The content which students study in an up-to-date programme will be partly out of date before they can apply it in practice. Mastery of subject matter which has only emerged since they graduated will be required of them (see Challenge 8).
- During their professional practice, graduates will then have to engage responsibly and effectively with their own professional development, both immediate and long-term; higher education must therefore devote time (taken from disciplinary subject coverage) to equipping them with the skills for self-directed lifelong learning (Candy 1991).

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Consequently assurance of the quality, an overall process leading to a licence to practice, must now cover mastery of content encountered after graduation coupled with a reasonable assurance of their ability to master new content and skills. To this demand should be added the complication that the processes of professional bodies have, in the main, been self-assured (see Challenge 5, below).

At least one professional body outwith engineering, namely the Chartered Institute of Personnel and Development, has dealt with this in an imaginative way (Chartered Institution of Personnel and Development 2005). This body recognises that its QA procedures, as a professional body, cannot cover all that is required if there is to be thorough oversight of its professional accreditation. They therefore co-ordinate with universities in the provision of supplementary activities, external to degree programmes – for example, in human resources management. The Institute specifies the coverage, standard and assessment of such provision – and remits it, in partnership, to a collaborating university's QA procedures to cover the additional professional provision, as well as the academic degree programme (Francis and Cowan 2008).

Is this not a possible way ahead for engineering education? The learning and development required for professional accreditation go beyond the coverage of an undergraduate degree. The assessment of this should surely be left, as before, with the professional body. However, the QA of the total process should be a holistic confirmation of quality, probably integrated with the procedures of the university, while remaining open to scrutiny by the professional body. In other words, I advocate and forecast within Europe an integration of QA procedures for both degree programmes and professional validation.

Challenge 6: Ensuring Informed, Independent and Objective Oversight

Before we had any procedures for QA, it was common to judge personal or group teaching performance against somewhat vague criteria, which were personally determined or set by individuals or a programme team. Usually this activity was based merely on impressions of the situation being judged, rather than on objective data assembled to describe the situation and learning outcomes.

The subsequent development of QA approaches (Harvey 2005) has arisen from reasonable reservations about this process, which thoughtful observers and participants had formulated. They noted commonly occurring situations in which those who planned and delivered and assessed programmes also acted, in effect, as custodians of their own standards. The move towards objective self-evaluation has certainly been accompanied by an expectation that criteria and sources of data will be declared, explicit, and transparent. It has also been followed by the (reasonable)

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view that externality, at least internal externality, is desirable, when judgements are being formulated.[2]

We still have some way to go before externality is specified as an essential feature of quality reporting and of review. Beyond that goal, we will then need to ensure that those who contribute to review as externals are adequately trained or prepared to follow, and if necessary insist upon, an objective process. This is perhaps especially so in the case of an international dimension to externality, both with the envisaged establishment of international agencies, in the context of Bologna, and also with the fact that in small countries or specialist disciplines, in which everybody in HE knows almost everybody else, competent and independent externality will be an important and desirable feature of assurance.

Challenge 7: Increasing Educational Professionalism

A generation ago, those who taught engineering were usually professionally qualified – in their discipline of engineering. But the notion of being professionally qualified to plan provision, to deliver teaching and to assess was seldom aired. Some academics concentrated upon research or consultancy; the majority, in their teaching, relied on their own past experience and common sense, often merely justified as meaningful *gut reactions*, which they would have been hard pressed to distinguish from indigestion.

There followed perhaps 15 years of gentle transition, in reaction in mainland Europe to the students' revolts of 1968. Project-oriented learning often replaced didactic instruction (Kjersdam and Enemark 1994). A minority of teachers were minded to develop their teaching founded upon an acquaintance with basic research findings regarding pedagogy. A few enthusiasts and visionaries began to offer what they called *freedom in learning* (Rogers 1969) or *independent learning* (Robbins 1988). And in some universities in some countries, attempts were made to provide training for newly appointed or otherwise interested lecturers in the areas of teaching, learning and assessment.

[2]I take externality in quality judgements to mean the primary involvement therein of persons who are external to the programme or activity whose quality and standards are being judged. I take internal externality to describe the usefully constructive process by which judgements are made by colleagues in the same institution, but drawn from different discipline areas. External externality involves at least some completely independent panel members, who bring even greater detachment and useful breadth of experiences to the process.

Inexorably external agencies were required by society and established initially to judge the quality and standard of programmes in higher education. Nowadays they are more likely to have to scrutinise the manner in which the institution satisfies itself with regard to the standard of its awards, and the quality of the learning experience it provides. Programme teams and disciplinary schools have naturally become increasingly adept at tactically assembling data, or fragments of data, which can influence visiting panels to form favourable judgements. In response, zealous auditing teams, internal as well as external, have acquired skills of probing enquiry, to ensure balanced and rigourous judgements!

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In Britain, by 1990, most universities were expecting new appointees to undertake training. A consequence of the Dearing Report (HMSO 1997) to government, and the decisions arising from that, has been that induction training will become mandatory in UK, around the time of writing. This has had a noteworthy effect on the pedagogical knowledge base which now informs curriculum development, review and QA. Lecturers are expected nowadays to have engaged and continue to engage proactively with the Scholarship of Learning and Teaching (Boyer 1990, 1998), as it has been called.

Each year, a further cohort of moderately revolutionary *Young Turks* emerges from training programmes into practice. They have qualifications and engage in creative thinking about their curricula which has been stimulated by their studies for postgraduate certificates in higher education. Increasingly they are a strong, dominant and informed voice in decision-making groups. Additionally, each year, the inexorable march of time brings about the professional demise of some of the *Old Guard*. For a changing of the guard inevitably occurs with their retirement, removing much diehard educational conservatism in consequence.

This progression is tangible, and is now by no means slow. Since 1990, publications on staff and curriculum development have rapidly become more and more professional, more based upon properly evaluated pilots and formulated theories, and less on anecdotal accounts of innovation accompanied by enthusiastic endorsement from the innovators. Higher education is therefore fast earning itself the right to be regarded as a professional practice. It is increasingly based, just as a profession such as engineering should be, on familiarity with a sound knowledge base, on generally accepted and proven practice and on developments emerging from ongoing research (Rushby and Cowan 2006).

However, a new hazard to quality and standards has emerged. This challenge presents an interesting dilemma – in that whilst many who teach now have training in teaching, increasingly engineering departments are staffed by non-engineers, or at least by some without professional experience or qualifications. So what is the impact of this on the quality of engineering education presented? This becomes a really important issue in the area of design education, where many of the staff may have no engineering design experience.

Inevitably, QA activities in the future will also be increasingly founded upon the professional base of our new discipline of higher education, yet engineering education should surely still depend on the professional competence of staff as engineers. QA will prompt development of both aspects of that base and the enhancement (Raban 2007) of HE provision. It will do so with agenda items arising from questions, issues and examples of good practice which are identified during QA activities and international scrutiny of these, arising in consequence.[3]

[3] A European colleague commented (Oliveira 2008) that in the last few paragraphs of this section, I concentrate on the British QA reality. It is his belief that a brief view of what is happening, or not yet happening, in the rest of Europe would illustrate how much diversity exists, and that Britain is probably years ahead of much of the rest of Europe. I concur, but would not wish to make invidious comparisons here in any detail.

Challenge 8: Continuing Professional Development

One consequence of the information explosion has been recognition in most professional areas of the need to ensure that practising professionals continue to undertake adequate professional development. They should update their knowledge and skills, and even uprate them. However, most of the arrangements which have been made to date with this end in mind are somewhat suspect in terms of assured quality. It is common nowadays for professionals to maintain a record of their attendance at CPD events or of other activity which they claim has contributed to their development. Yet even certificates of attendance (commonly issued and retained) do not certify that the attendees were awake or attentive during the session. They certainly do not attest to retained learning or development, which is what important in worthwhile CPD.

It is rare – very rare at present – for any cheque to be made of the standard of learning and development claimed in CPD, or of the effectiveness of the learning or developmental experience. Yet these features are now basic and vital constituents of a QA approach to formal graduate education. It seems likely, and highly justifiable, that a society which looks for QA of the education provided by universities, should soon expect a similar oversight in respect of CPD, whatever provider or manager is involved. In similar vein, society also remits to us the recognition and accreditation of Prior Learning, a much talked about issue, whose practices lack insight, experience, consistency and rigour, and which therefore should also be subject to QA procedures. I would hope that this will be yet another example of a feature in which post-Bologna comparisons will lead to the identification of discrepancies judged to be important, with the consequence that pressure will be brought to bear on weaker providers (and national practices).

Conclusions or Predictions

From the thoughts I have set out here, I am suggesting that the future, as far as QA in engineering education in Europe is concerned, will bring:

- Greater and more consistent rigour in QA processes
- More emphasis on providing effective teaching for the attainment of higher-level learning outcomes
- The development of sound methods of assuring the quality and standards of the attainment of higher-level learning outcomes, both cognitive and interpersonal and including professional competence
- Externality becoming an accepted and routine feature of the reviews and audits in QA
- QA activities which will build upon the professional base of our new discipline of higher education and which will prompt development and enhancement.
- Forceful efforts by the European Community to establish comparable criteria and methodologies for QA in higher education, which will have a powerful

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impact on generic requirements that were not designed with engineering specifically in mind.

- Steps to tackle the demanding challenge of assuring the quality of the CPD which so many professions now require – and accredit.

I envisage these as changes in the future, though certainly not in all cases in the near future! Nevertheless, as my Portuguese colleague (Oliveira 2008) wisely points out, QA in Europe may well be regarded not only as a tool for transparency and mobility, but also as a tool for the reform of European higher education, as envisioned in the Bologna Declaration.

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