Meeting the Educational Needs of Emerging Technologies Alongside Traditional Disciplines

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Abstract: The traditional engineering curriculum, based for the most part on science and mathematics, is inappropriate for educating engineers in the 21st Century and does not in general appeal to the majority of young people who may contemplate a career in engineering or technology. Engineering departments in the UK are suffering from a combination of a reduction in the numbers of applications to traditional programmes and at same time from a decline in the country's industrial base. Creative industries, screen, music, fashion, design, journalism and sport however, are expected to outstrip growth in all other sectors.

The Division of Electronic Systems in the School of Engineering at the University of Derby has developed two degree programmes to meet the technological advances in the music industry, which is one of the largest and therefore plays an important part in the economy of the country. One programme is titled Music Technology and Audio Systems Design, with the emphasis on the music studio. The other programme, titled Live Performance Technology looks at the other end of the market in terms of both the audio and lighting used, for example, in a stage performance. Many universities in the UK have gone down the media and multi media route where little in the way of traditional engineering fundamentals and principles are developed. The division however, decided to link the new programmes with the traditional disciplines of Electrical and Electronic Engineering. Many universities have opted for programmes which include music technology and audio electronics but the second programme is believed to be the first of its type in the UK.

This paper considers the need to develop programmes of study which retain engineering principles and provide an applications bias towards emerging technologies. The skills obtained from this type of programme provide opportunities world-wide and the potential creative, as well as problem solving aspects, provides a high degree of job satisfaction.

Key words: curriculum design, emerging technologies

Introduction

A decline in the number of students entering engineering programmes has been problematic for the majority of institutions of higher education in recent years. There are many reasons for this decline but two of the main reasons are that feedback from schools indicates that engineering has a poor image among young people and school leavers are equipped with inappropriate 'A' levels or other qualifications to enter engineering programmes of study. The raising of standards by the Engineering Council for professional registration in their 3rd edition of Standards and Routes Towards Registration (SARTOR) in 1997, which have been phased in from September 1999, is likely to worsen the situation for all but the top ranking universities.

Brown [1] describes the looming shake out for universities and poses a number of scenarios as to the future of engineering in this sector. There are however, universities who have already stemmed the decline or have even reversed the decline into a situation of growth by introducing programmes of study which include the word technology instead of engineering in the title, or using other more appealing titles. Many of these programmes are non-accredited and therefore their future is unaffected by SARTOR. A niche in the market place has been created and many of these programmes have experienced rapid growth. This has partly been achieved by the programme titles that are better received by young people and partly by widening but not reducing the entry criteria.

Departments and Schools of Mechanical and Manufacturing Engineering have moved into the market of programmes which include product design whereas those in the business of Electrical & Electronic Engineering have developed programmes in the area of media or information technology. This move has often been made possible by the merging of departments for example Technology and Information Systems formed from Engineering and Computing. Many of these niche market programmes include little in the way of traditional engineering

fundamentals and principles and are quite often described as 'soft' engineering options by both academics and the students who study them. Despite some universities being able to offer traditional and niche market programmes the former may have limited life as the new SARTOR input standards take effect.

The need to 're-engineer' the engineering degree course is described by Marsh [2]. He refers to a rapid shift in programmes offering the application of technology and highlights that many traditional programmes contain significant elements of curriculum which the graduate engineer will never use such as demanding levels of mathematics. The case is also made for a revision of teaching, learning and assessment strategies with more emphasis on key skills such as communications, numeracy, use of information technology and learning how to learn.

'Bolting on' to existing programmes

Naturally, an easy option for the curriculum designer is to 'bolt on' a small number of modules, that give a flavour of the programme title, to an existing traditional programme of study, for instance, Electrical and Electronic Engineering. The added flavour may not be available until the second or final year of a three year degree programme and is likely to be offered in the way 'option' modules added to an existing programme. This approach enables new programmes to be created within minimum cost in modular schemes and has been practised for some time, for example, in a 'common' first year for programmes in Electrical Engineering and Mechanical Engineering. Whilst it is acceptable to have common modules in subject areas such as those described, it is more difficult to adopt this approach in subjects such as music technology.

Experience in the early years of introducing music related programmes at my institution has shown that 'bolting on' is likely to lead to a number of problems, the main ones of which are now described. The most significant problem is with student retention and progression. The amount of specialist study in the first year and particularly in the first semester is crucial to setting the level of retention. Students tend to drift in the first semester and many do not return, for example after the Christmas break to complete the second semester of the first year. There is 'drop out' in any programme of study particularly in the early weeks, however the situation is usually worse in the 'new' technology programmes. Our own progression rate in the first year was around 60% when we first recruited to a programme with the title Electronics with Music Technology. This low percentage is attributed to drop out in the first semester caused mainly by the student perception of 'lack of relevance' of much of programme content and by significant failure at the end of the first year in the traditional engineering modules such as Mathematics and Electrical & Electronic Principles & Theory. The 'bolting on' effect is therefore considered to have been a major factor in this poor progression.

The progression rate at Derby has been improved to just under 80% and this has been achieved by careful curriculum design which has included an increase in the number of modules and programme themes which reflect the programme title. The programme title of this first venture into a 'new' technology programme some six years ago has been changed to Music Technology and Audio System Design which better reflects the programme content. Choosing the 'right' students in the first place is also crucial to success. Input standards have been set relatively high for this programme which is currently in excess of 17 'A' level points or equivalent. Open days and interviewing of potential students has also been crucial to the success at Derby. Students will soon become disillusioned if they have been coaxed onto a programme only to find limited resources in the subjects they have come to study. Interviews are important as there is the opportunity to find out what students' aspirations are. For example an overview of the curriculum content presented at open days plus a personal interview can be used to explore whether the potential student really wants to learn about, say electronics, or would be more suited to a media programme.

Curriculum Design

The majority of institutions who have engineering faculties or schools will have a portfolio of programmes which include traditional engineering disciplines. Vocational programmes can be added to a portfolio and links with existing programmes can be developed by the curriculum designer. Alternatively new programmes can be developed in isolation to any others even though they may share some resources.

Many technology programmes, for example those labelled media develop little in the way of engineering fundamentals whilst at the other extreme engineering programmes such as BEng/MEng provide an excellent grounding in fundamentals and in the theoretical aspects of electronic and electrical engineering. Whilst media programmes have their place and satisfy a need in the recruitment market and subsequent job market and can have strengths in developing intellectual skills such as creativity, there is a middle of the road option.

Evidence shows that programmes labelled 'technology' are more popular than those labelled 'engineering'. Curriculum designers can take the middle of the road option and give programmes a 'technology' title yet still develop fundamentals to an appropriate level. The outcomes from such programmes can be developed to overcome

the deficiencies presently expressed by employers and can still contain creative themes which are much needed to assist motivation and provide a balance with fundamentals.

Media and IT programmes are likely to include little in the way of fundamentals in subject areas such as electrical and electronic principles, linear and digital electronics and electrical measurements and testing. The engineering applications theme is also likely to be absent. It is quite true that these omissions may be perfectly acceptable in these types of programmes. Market forces dictate their success but evidence clearly indicates they attract a larger number of potential applicants than traditional programmes and the explosion in the entertainment industry has created adequate job opportunities. However, such programmes may not be suitable for accreditation at either chartered (CEng) or incorporated (IEng) level but lack of accreditation is unlikely to affect their popularity and many institutions will continue to develop programmes in media and IT.

Increasingly there is a need for multi-disciplinary engineers and the educational base therefore requires an integrated curriculum. A model that has a base of electrical and electronic engineering and demonstrates the need of increasing interaction with Electronic Information Systems and Computer Science is described by Lee and Messerschmitt [3]. This model is easily adopted to provide the educational needs that combine traditional engineering with emerging technologies. Since 1996 the Division of Electronic systems has developed programmes as a portfolio and the present day curriculum model is shown in Fig 1

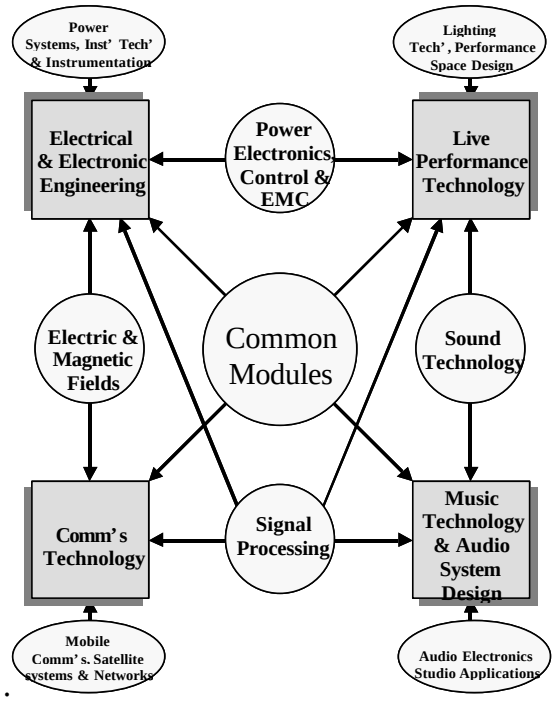

Fig 1 Curriculum model used at the University of Derby

The shaded boxes in Fig 1 represent the four programmes of study. Development as a portfolio and the strong links between the programmes through the use of 'common' and other 'shared' modules facilitates efficient delivery and management. Further aspects on this approach are described in [4]. The Music Technology and Audio System Design programme was developed alongside the Electrical and Electronic Engineering programme in 1996 and the other two added in 1999. Since all of the programmes are applications based they are accredited by the Institution of Incorporated Engineers (IIE) meeting the educational requirements for incorporated engineer (IEng) status.

Each programme develops specialist knowledge as well a generic skills which include key skills. A status matrix for each programme at level 1 is shown in Fig. 2

Common Modules	**BSc (Hons) EEE**	**BSc (Hons) MTASD**	**BSc (Hons) LPT**	**BSc (Hons) CST**
Quantitative Methods	**C**	**C**	**C**	**C**
Technology Skills & Practice	**C**	**C**	**C**	**C**
Digital Electronics	**C**	·	·	**C**
Electrical & Electronic Principle & Thry	**C**	·	·	·
Communication Technology	·	·	·	**C**
Electrical Measurement & Testing	·	·	·	·
IT & ECAD	·	·	·	·
Specialist Modules				
Electrical & Electronic Services Design	·	-	-	-
Electric & Magnetic Fields	·	-	-	·
Midi Apps & Sound Synthesis	-	**C**	-	-
Music Theory	-	·	-	-
Sound Technology	-	**C**	·	-
Light & Optical Theory	-	-	**C**	·
Live Performance Space	-	-	**C**	-

Fig 2 Status matrix – level 1 modules

Common modules appear at all levels but an increased number of specialist modules are available at the higher levels 2 and 3. Each programme requires a core but the core modules defined as C in Fig 2 needed careful thought during the curriculum design stage. As can be seen some are common modules where others are specialist modules reflecting the programme title.

Unlike many of the 'softer' arts/media programmes the portfolio of programmes emphasises the need for a degree of mathematics and engineering fundamentals to ensure underpinning of certain modules in the latter stages of each programme. The level and amount is less than the expected of a BEng programme nevertheless modules devoted to mathematics, electrical & electronic principles etc. are studied by students on all programmes in the portfolio. Whilst mathematics can be hidden in other modules the question is always raised as to whether engineers or mathematicians can make a better job of delivering the content.

Educators are faced with the problem of satisfying the requirements of the Quality Assurance Agency for HE, accreditors, awarding bodies and others with respect to incorporating generic skills into their programmes of study. The possibilities are overwhelming [5] when the ability to resource the requirements are questioned. The choice of core modules and formulation of generic skills and their subsequent mapping in these programmes is fully described in [6].

Teaching, Learning and Assessment

There is a significant emphasis being placed upon the gradual movement from traditional teaching methods to student centred learning. Student staff ratios (SSR) are increasing with many universities having to exceed 20:1 in order to survive the economic constraints placed upon them. The use of common modules has helped to improve the efficiency of delivery and increase the SRR since lectures can be delivered to numbers approaching 200 in these modules. It is however tutorial and laboratory time which requires the greatest formal contact. Programmes with an applications bias tend to require more laboratory tuition and practical skills based activities that generally improve motivation. Whilst the majority of universities provide increased computer aided learning (CAL) support for tutorials and to replace traditional laboratory work the model at Derby aims to strike the right balance and to utilise

information technology to encourage creativity. The division has not directed significant expenditure towards developing or purchasing CAL packages but instead has invested heavily in workstations for practical work with computer aided assessment facilities and in industry standard software such as P-spice, EDWIN, MATLAB, Simulink and other specialist software in music technology etc.

A major theme in all programmes is signal processing as shown in Fig.1 where the traditional approach emphasises understanding the mathematics underpinning the subject. Engineers today need to be creative and adapt to changing situations. This requires a different approach to the teaching/learning strategy [7].

Outcomes based assessment is being adopted more widely in the UK but the QAA will expect all institutions to adopt an outcomes based approach in the near future. Many universities claim to be using outcomes based assessment but in reality have done nothing more than to re-name their programme specific objectives as learning outcomes. There is little evidence that these outcomes are followed through to assessment.

The programmes feature a full achievement outcomes based assessment model. There is therefore no compensation between components of assessed coursework or between cour sework and examination components as each component addresses a learning outcome(s). In exceptional circumstances the assessment board may compensate for a marginal failure in a learning outcome if others are graded well in excess of the threshold level for a pass grade. Experience since 1996 in the learning outcomes approach has led to a number of revisions particularly in the area of over assessment and in the specification of outcomes, assessment criteria and methods of assessment. This has resulted in an assessment template as outlined in [8].

Conclusions

Would study programmes in music technology however attract students? The BSc (Hons) in Music Technology and Audio System Design when launched in 1996 attracted 25 students. The intake in 1998 had risen to almost 100 with the assistance of a foundation year. The BSc (Hons) in Live Performance Technology was first offered in 1999 and attracted 25 students. The division continues to offer a traditional programme in Electrical and Electronic Engineering which, although showing no sign of growth, will continue to be offered as it is supported by local industries. Despite a number of similar music related programmes evolving throughout the UK the market does not yet appear to be saturated.

It is too early to state the effects of introducing the new assessment template as results will not be available overall until late June 2000. It is anticipated that initially there may be an increase in the number of referrals. Staff as well as students need to adapt to the new approach since there is a tendency to cling to the traditional approach with which they are both completely familiar. Some staff development has taken place and students have been made aware of the requirement that credit is only awarded on the successful completion of the learning outcomes specified in a module. The biggest hurdle for staff appears to be in designing appropriate assessments to meet the outcome, particular in respect of examinations. Students on the other hand still tend to think there will be some form of mechanism to enable compensation, for example, in failing to submit an assessed assignment which address a learning outcome they make the incorrect assumption that they will be compensated if they do well in other assessments.

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