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ABSTRACT

Students enrolled to degree programs in 1997 will become the first graduates of the 21st century. Engineering courses in the School of Engineering at Leeds Metropolitan University have changed immensely in the last two years, so as to support new markets. Disciplines such as industrial engineering, electronics and computing have enjoyed their birth, growth, and maturity during the past thirty years. The more recent past has seen a move to include multi-media technology as a generic skill. The final years of the 20th century see engineering students who are less interested in theoretical principles, mathematical concepts and research-focused courses. Furthermore, employers, government and planners of the shape of the engineering profession are seeking different attributes from engineering graduates which will greatly influence the programs of the next century. The graduate of the future is expected to exhibit a totally different range of skills from their forebears. The workplace for engineers often considers communication skills to be more important than high level mathematics, group working skills more important than academic individuality, and a commitment to lifelong learning and continuing professional development, in most cases, offers more to employers than a theoretical contribution to research focused projects and developments. Students have become more thoughtful and focused about their career aspirations. They demand more opportunity to influence their educational development than has ever been the case. The introduction of tuition fee contributions in the UK, from 1998, will create greater demands and expectations from the student population. Traditional engineering programs contain significant elements of the curriculum which the graduate engineer will never use. Mathematical excellence seems an obsession of engineering programs, yet experience of the author shows that most engineers are employed in roles which demand a much less demanding level of mathematical ability. The comments mentioned above interact in a curriculum sense to produce contradictions in programs; the solution represents the ingredients for many of the programs of the future. The engineer of the next century must exhibit a range of skills and experiences which differ immensely from those of only twenty years ago. Program delivery modes, experiential contribution, and learning outcomes must, more than ever, be central considerations of courses. Applications of technology are crucial aspects which have greatly influenced program design at Leeds Metropolitan University. Redesign of the portfolio of programs in the School of Engineering has been very conscious of student aspiration and employer demands. Developing group and team working abilities, project management, and other generic skills for employability are a central focus of our programs. This is coupled with the development of a flexible learning environment where

attention to pedagogic integrity is being inculcated in staff development programs. Faculty are being driven down the road of facilitating learning in an environment where direct contact time with students has reduced and is expected to reduce further. Students are being trained/developed more rapidly to be independent learners and academic emphasis is interwoven with peer assessment, integrative development, measurement of learning outcomes, goal setting, flexible learning, and employment skills. This paper charts the experiences of the School over the past 24 months in restructuring to meet these demands. (Author)

RE-ENGINEERING THE ENGINEERING DEGREE COURSE

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Abstract

Students enrolled to degree programmes in 1997 will become the first graduates of the 21st Century. Engineering courses in the School of Engineering at Leeds Metropolitan University have changed immensely in the last two years, so as to support new markets. Disciplines such as industrial engineering, electronics and computing have enjoyed their birth, growth and maturity during the past thirty years. The more recent past has seen a move to include multi-media technology as a generic skill.

The final years of the 20th Century see engineering students who are less interested in theoretical principles, mathematical concepts and research focused courses. Further more, employers, government and planners of the shape of the engineering profession are seeking different attributes from engineering graduates which will greatly influence the programmes of the next century. The graduate of the future is expected to exhibit a totally different range of skills from their forebears. The workplace for engineers often considers communication skills to be more important than high level mathematics, group working skills more important than academic individuality, and a commitment to lifelong learning and continuing professional development, in most cases, offers more to employers than a theoretical contribution to research focused projects and developments.

Students have become more thoughtful and focused about their career aspirations. They demand more opportunity to influence their educational development than has ever been the case. The introduction of tuition fee contributions in the UK, from 1998, will create greater demands and expectations from the student population.

Traditional engineering programmes contain significant elements of the curriculum which the graduate engineer will never use. Mathematical excellence seems an obsession of engineering programmes, yet experience o the author shows that most engineers are employed in roles which demand a much less demanding level of mathematical ability.

The comments mentioned above interact in a curriculum sense to produce contradictions in programmes; the solution represents the ingredients for many of the programmes of the future. The engineer of the next Century must exhibit a range of skills and experiences which differ immensely from those of only twenty years ago. Programme delivery modes, experiential contribution and learning outcomes must, more than ever, be central considerations of courses. Applications of technology are crucial aspects which have greatly influenced programme design at Leeds Metropolitan University.

Redesign of the portfolio of programmes in the School of Engineering, has been very conscious of student aspiration and employer demands. Developing group and team working abilities, project management and other generic skills for employability, are a central focus of our programmes. This is coupled with the development of a flexible learning environment where attention to pedagogic integrity is being inculcated in staff development programmes.

Faculty are being driven down the road of facilitating learning in an environment where direct contact time with students has reduced, and is expected to reduce further. Students are being trained/developed more rapidly to be independent learners and academic emphasis is interwoven with peer assessment, integrative development, measurement of learning outcomes, goal setting, flexible learning and employment skills.

This paper charts the experiences of the School over the past 24 months in restructuring to meet these demands.

Introduction

The last twenty-four months has seen the most significant change ever experienced by any engineering school with which I have been associated. This has been brought about by a recognition of the need to re-design programmes of study, change the working culture and the need to introduce new teaching and learning practices into the School. Whilst introducing a culture change in itself presented a large challenge, the convergence of several other factors into the same period of time enhanced the challenge to dauntingly large proportions.

In 1996, the School of Engineering was perceived by the University to be over-staffed and a very poor performer against certain key indicators. Furthermore, the traditional undergraduate population of electronics

engineering and manufacturing engineering students was shifting rapidly towards programmes offering applications of technology as their main feature.

For example, Multi-Media Technology and Music Technology.

External to the University extremely significant and influential projects where underway at Government level as well as within the structure and fabric of the engineering profession.

These factors together with a requirement to review the total engineering programme provided a cocktail of ingredients which, made vision, strategic planning, project management, leadership and team working absolutely essential attributes of the team who were to plan and develop programmes and courses for the four years leading into the next millennium.

In addition, programme developers needed to address the demands of potential employers who required a range of generic skills from graduates which would allow them to move straight into value adding roles with little or no company based development phase.

The above constituted a group of pressures which required the programme re-development team to reposition the School so as to benefit from the changing demands of the market place and stakeholders.

Background

a) The Higher Education sector in the UK has expanded over six years, to around one-hundred-and-fifteen universities and colleges of Higher Education offering degree level study. In the same period, the participation rate of high school leavers has grown from eighteen per cent to thirty per cent. Universities have developed a range of new degree titles to attract the expanded market.

b) Government investment in HE has not kept pace with increased participation rate with the result that departments are less well funded than at the beginning of the decade and many have less faculty members to support students. As a result, either students receive less formal contact with teachers, or individual courses are used by more programmes so as to herd students together into larger groups for lectures. Often both solutions are used.

c) Many students have no option but to work so as to pay their way through university. Until the 1990s working to finance study commitments was not a common feature of University life. Evidence of students being unable to attend some lectures because of the need to work has become more prevalent.

d) Two national initiatives were to come to their conclusion in 1997. One was a National Committee of Enquiry into Higher Education chaired by Sir Ron Dearing [1] and working to terms of reference laid down by the British Government. The opening statement in the terms of reference was:

"To make recommendations on how the purposes, shape, structure, size and funding of higher education, including support for students, should develop to meet the needs of the United Kingdom over the next twenty years, recognising that Higher Education embraced, teaching, learning, scholarship and research" "The Committee should report by the summer of 1997."

The other national initiative was the review, by the engineering professions governing body, The Engineering Council, of regulations governing the approved 'standard and routes to registration' as a Chartered Engineer (SARTOR) [2].

e) This period coincided with a greater recognition of the fact that a graduate education is only the beginning, especially so with technological subjects, of a lifetime of learning, retraining and continuing professional development.

f) A recognition, by a growing number of companies, that a set of core competencies are an essential pre-requisite for consideration for employment.

g) Pressure had been brought, over a short period, on universities to put forty to fifty per cent more students (including mature and part-time) through courses with a gradually reducing level of government funding.

Without doubt, universities in the UK are being required to do more with less. They have less money, students receive less formal contact time, we are required to increase access, be more flexible in our approach to learning, and add more value to students. If we need a challenge this is it!

Key Observations Which Influenced the Programme Design

Of the many recommendations to come out of the Dearing Report [1] one had particular influence on organisation and delivery of the new engineering programme. This was the recommendation that institutions should immediately begin to develop learning outcomes for degree programmes in terms of four key skills; communications, numeracy, use of information technology and learning how to learn. This is not to suggest that these four key skills did not feature in engineering programmes at Leeds Metropolitan University, as evidence by the compliments paid by German exchange students. However, the support for these skills was revisited and further strengthened in the new programmes.

The importance of these skills is emphasised by Gareth Rhodes, accreditation adviser to the University of Northumbria in Newcastle, UK, who "believes that key skills ought to be at least as important as

specialist knowledge". He is quoted as saying that "a significant school of thought believe that key skills should be the main emphasis of academic programmes. Specialist knowledge would then be relegated to second place" [3].

The pressure for universities to embrace key skills is being driven by the needs of employers.

By the end of this Century it is expected that small and medium sized enterprises will employ more graduates than large corporations. This realisation has significant implications for the future of expensive graduate training schemes which are the preserve of larger companies [3].

The four key skills identified by Dearing [1] are more succinctly described as [3]:

- personal skills such as the ability to improve own learning and action planning.
- interpersonal skills such as working with others.
- communication.
- literacy.
- information technology skills.
- problem solving including critical and lateral thinking.
- reflection and objective reasoning.
- positive attitude to change including understanding the world of work, politics and society.

These are important recommendations since Professor Murphy of Nottingham University, School of Education, conducted research in 1997 which showed that "just 18 per cent of new undergraduates were competent in communication, numeracy and information technology" [3].

In February 1997, the Royal Society, Royal Academy of Engineering and the Engineering Council jointly sponsored a seminar entitled "Engineers - The Supply Side" [5]. The Seminar focused on the motivation, preparation and formation of engineers. The executive summary of proceedings refers to the fact that:

> "Students learn more effectively when they are actively involved both in the learning process and in the processes of the discipline. Students should be given increasing responsibility for taking charge of their own studies" and that "courses should contain open-ended, constructive, inventive and investigative practical project and assignment work, involving groups of students [5].
>
> The seminar also commented that:
>
> "Courses should contain open-ended, constructive, inventive, and investigative practical projects and assignment work, involving groups of students"

Some very hard decisions had to be made when deciding the philosophy, aims and objectives and thrust of new engineering programmes in the School of Engineering.

The debate at The Engineering Council (EC) concerning new SARTOR guidelines were clearly going to mitigate against many universities in the UK. The EC planned, and finally approved in 1997, a restriction on programmes which meet the educational requirements for Chartered Engineering accreditation. This they would achieve by requiring a four year university programme (MEng), or three year (BEng) plus an associated matching section. Additionally, and more significantly, the EC had decided that entry to both MEng and BEng programmes should be restricted to students with high A-Level grades (high school leaving examinations). Despite massive lobbying from universities, who argued that adding value and achieving output standards was more important than controlling input standards, the EC was determined to impose requirement for at least twenty-four A-Level points for entry to an accredited MEng and at least eighteen A-Level points for entry to an accredited BEng.

Aitchinson [4], using statistics available from the Higher Education Statistics Agency (HESA) for the 1995/96 academic year for various engineering disciplines shows that only 18.9 per cent of first year intake satisfy the SARTOR requirements for MEng programmes. For BEng programmes the figure was 33.3 per cent of the national intake to engineering programmes.

In practice, the distribution would be concentrated on a small number of universities.

Whilst most, if not all, engineering schools have decided to wait until the introduction of the new SARTOR in 1999 to act, it was appropriate for Leeds Metropolitan University to use the new programme development to restructure and re-focus the programmes with SARTOR 97 in mind.

Impact on Programme Development

Programme development has been aimed at satisfying a number of Stakeholders including, students, industry, the engineering profession, funding bodies and the University.

Any broad scheme which is developed must be able to efficiently support a number of programmes by share learning material (courses) from a limited pool. The broad scheme therefore, aimed to address and embrace:

i) unsatisfactory attrition rates.

ii) the national changing requirements for registration as a Chartered Engineer.

iii) the growing unpopularity of traditional engineering disciplines such as manufacturing and electronics engineering as <u>full-time</u> courses.

iv) the clear market for <u>part-time</u> programmes leading to Chartered Engineer status, including manufacturing and electronic engineering.

v) a clear perception that courses concentrating on the application of technology, especially in newer disciplines, are very marketable to the full-time student population.

vi) a need to manage and control faculty input to course delivery within the confines of what is economically justifiable.

vii) a clear requirement for a significant staff development initiative so as to cope with:

a) The changing specialism and emphasis of programmes and courses.

b) The need to move away from teacher led activity to facilitating and supporting the learning process.

viii) encouraging and developing skills within students which allow them to become independent learners.

ix) promoting and developing generic key aspects of sustainable employability ie team working, communication skills, presentation skills etc.

x) recognising that through pressures to earn money students are not always able to attend a fixed slot in the academic week.

xi) accommodating the realisation that student expectations will increase if, and when, they are required to contribute financially towards the cost of their higher education.

The outcome was a carefully costed broad scheme supporting a number of programmes of study which are leading to several named awards. The awards are listed below:

Certificate in Key Engineering Skills
Foundation Engineering (September start)
Foundation Engineering (February start)
BEng (Hons) Electrical Systems Engineering (Part-time only)
HNC/HND/BSc (Hons) Electrical Media and Communications
BEng (Hons) Electronics and Communications Systems (Part-time only)
BEng (Hons) Electronics, Music and Media Technology
BEng (Hons) Manufacturing Systems Engineering (Part-time only)
HNC/HNC/BEng (Hons) Technology and Management
HND/BSc (Hons) Multi-Media Technology
HNC/HND Electrical and Electronic Engineering (Part-time)
HND Musical Instrument Technology
BSc (Hons) Music Technology
BSc (Hons) Print Management

Impact on Support for Learning

As engineering teachers, we mainly exhibited traditional conservative views on delivering higher education courses. The model which most faculty had grown used to was a one (or two) hour slot each week for delivering lecture material which is supported by a one (or two) hour block in a laboratory, computer suite, tutorial or seminar session. In other words, every course was timetabled for around three hours per week of class contact time with their teacher. Often a course is shared between two, three or four members of faculty and so students may well be exposed to ten to fifteen teachers per semester.

In this didactic situation learning is very much directed by the teacher and students are less likely to know who their tutors are. The result is that care of the student (customer) is poor.

There are many reasons why the effectiveness of this approach needed to be challenged:

i) it could be argued that the curriculum is/was loaded with significant chunks of unnecessary material so as to ensure the three hours per week are full, busy and contain appropriate topics to sustain the ego of the teacher.

ii) students taught in this situation resort to rote learning, collecting banker questions, concentrating on sixty per cent of the syllabus etc so as to reach the pass mark for the examination.

iii) the programme was only thought to be challenging and of a high standard if the student timetable was full and busy for eighteen to twenty-four hours per week.

iv) a busy timetable leaves little room for reflection and limited opportunity for developing key transferable skills.

An analysis of the student experience showed that attendance at lectures was declining, using a learning styles questionnaire, developed by Money and Mumford [7] students were found to be activists (54%) and pragmatists (25%) (8).

That the lecture situation was considered to be boring by many students was not surprising. I have heard reference to boring lecturers from across a wide variety of students, covering many disciplines, at a number of universities and yet, we believe that standing in front of a class is the only way to get students of many disciplines, including engineering, to learn.

The challenge facing faculty within the School of Engineering was to make:

- course delivery more flexible so as to cater for variation in attendance patterns of students.
- motivate students through the use of structured practical based learning.
- encourage students to develop a portfolio of work and evidence of learning.
- require students to reflect on the learning and retain a journal of thoughts and experiences associated with the learning.
- developing skills to be independent and life long learners.
- facilitating effective learning and maintaining academic standards whilst reducing the time provided for faculty to support course delivery.

This was achieved by replacing some lectures in favour of other methods aimed at supporting learning. Competency based assessment has resulted in students being required to collect evidence of competence. Faculty moved to team teaching, use of summative and peer assessment, problem based learning, group and work based learning and the use of open and distance learning.

A survey conducted by Professor Harold Silver, who is a visiting professor at the University of Plymouth has found evidence that these techniques are growing in higher education and being effective [6].
We needed to ensure that reduced time spent with students was useful time.

Impact on Staff Development

The introduction of new programmes will take three years to complete, with the first group of freshers entering in September 1997. This gave the School three years to introduce not only a new curriculum but to address a different teaching and learning strategy involving the development of independent learning skills amongst students, the introduction of an open and distance learning philosophy for course material, and new support and assessment mechanisms to cope with these changes.
The School developed a comprehensive staff development programme which put the thirty members of engineering faculty through an Advanced Professional Diploma in Teaching and Learning in Higher Education. Faculty will be developed through the diploma in groups of ten thus taking eighteen months to complete the process. (ie three groups x six months per diploma group). The diploma is validated and resourced through the School of Professional Education and Development at Leeds Metropolitan University and requires eight courses to be undertaken covering:

- Issues in Higher Education 1 & 2
- Teaching and Learning Strategy 1 & 2
- Assessment Strategy 1 & 2
- Student Support Strategy 1 & 2

These courses were followed by a negotiated learning contract and the submission of an 8000 work report on an agreed logic.
An extensive discussion of teaching and learning methods led the course attendees to conclude that engineering students at Leeds Metropolitan University were better suited to an "Evolution and Change Model" of learning, where the process of learning is reinforced at the input end by a recognition of prior knowledge and experience and supports a culture of continuing professional development at the output end.
Progress of the student within the model recognises the need to support and reinforce learning via a number of mechanisms, including work based, computer based and action learning. The model subscribed to the accepted notion of lifelong learning.
Faculty have been questioning the reason for a course within a programme of study. The traditional philosophy has been for courses to be used as building blocks of the larger programme where students are expected to digest the content of each course/block.
Rather than learning being pinned inside the Course and the property of the course teacher(s) the notion of level teams, who ensure that all learning outcomes are planned across a integrated curriculum, has evolved. This has led to team teaching, synoptic assessment models and the use of student portfolios as a means of recording and reflecting on their work and progress.

Concluding Remarks

Higher education in the UK is moving through a period of significant change. Student numbers have increased significantly, funding per students has reduced and from 1998 full-time students will be expected to contribute to the cost of their education. Additionally, for engineering departments the body governing the engineering profession has introduced a major overhaul to the route to registration which impacts significantly on engineering degree provision.
In response to these changes the School of Engineering has developed a much wider portfolio of courses which are attracting a broader and better qualified student base to the new programmes.
The School of Engineering is experiencing a huge shift in emphasis from preparing students to pass written examination to encouraging them to embrace a philosophy of life long learning, collecting evidence of achievements and reflecting on experiences. This is achieved within a project driven learning environment. Support for learning is being organised using small teams of staff for each programme level rather than the old model of bringing in possibly ten to fifteen faculty with specific expertise as and when aspects of teaching are required.
Flexibility of learning is being supported through the development of open and distance learning material. Initially the material will concentrate on courses offered in the early parts of the programme, but through a large staff development activity will spread across all courses over a three to four year period. Students will therefore, be able to access structured learning from a number of locations, including work, home or through a drop-in resources centre being built at the University.

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