Changes in Engineering Education in the United Kingdom

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Abstract

This paper provides an overview of the current status of engineering education in the United Kingdom. A comparison of traditional undergraduate and post-graduate engineering programmes offered by universities and technical polytechnics against proposed engineering & technology programs is highlighted in view of recent changes. In addition, current issues including student enrolment and graduates' professional development are described.

I. Introduction

The last thirty years, from the 1960s to the 1990s, have been ones of rapid change for UK higher education, especially in the realm of engineering education. The changes have concerned mainly externally driven issues of supply and demand, finance, structure and delivery modes. Internal issues such as the value and purpose of what is taught and how it is taught have also been subjected to changes. The external political changes have produced a greatly enlarged mass higher education system with a participation rate approaching that of the U.S.A., but without corresponding increase of funding. Moreover, the educational sector still retains many of the values of the former, rather elitist, system whereby higher education was for a relatively privileged few who were selected for their academic ability. These imbalances are the cause of many of the tensions that U.K. engineering education now experiences[13].

II. The Robbins and Dearing Reports

In the former period, the Robbins Report (1963) was a landmark for the changes in the 1960s, whilst changes in the later period 1989-94 are likely to be associated with the publication of the Dearing Report (1997). Let us examine their respective contributions in more detail. The five years following the publication of the Robbins report saw[13]:

- an expansion of student numbers and funding which in percentage terms more than matches recent experience;
- the creation of new universities;
- the transformation of the colleges of advanced technology into universities;
- announcements that established the polytechnics and the Open University;
- the establishment of the Council for National Academic Awards (CNAA) and of a new Department of Education and Science (DES);
- a substantial increase in overseas student fees

The raising of overseas students' tuition fees in the late 1960s began a process which continued through the 1990s and, more significantly, led to the development of an entrepreneurial approach to all sources of income other than that provided by Government Funding Council grants. Earlier university expansion was fully funded both for recurrent and capital expenditure. In contrast, the more recent expansion has been accompanied by severe reductions in unit funding, more intensive use of buildings and resources (staff included), and minimal contribution to capital development. This may be all that is needed to explain why changes in the 1960s took place in a mood of optimism about the future, whilst the more recent ones have been accomplished with pessimism and gloom, resulting in rather low staff morale and more mobility of staff out of the academic sector to the commercial and industrial sectors.

The most influential figure behind all the recent changes is likely to be Sir Ron Dearing. Dearing was drafted to chair the newly formed Polytechnic and College Funding Council (PCFC) in 1989 and the University Grants Committee in 1992, and he became the first Chair of the integrated body the Higher Education Funding Council for England. On Wednesday, 23rd July 1997 the "National Committee of Inquiry into Higher Education" chaired by Dearing reported back to the government in its report titled "Higher Education in the Learning Society". The committee was formed to look at and make recommendations on the purposes, shape, structure, size and funding of higher education. One of the main proposals in the report was that U.K. students (most of whom receive free tuition) should pay back a contribution towards tuition costs of £1000 for each year studied while retaining the current grant/loan split for cost of living expenses. This was to plug a nearly £2 billion shortfall in the funding of Higher Education over the next few years. The following extract is from Dearing's presentation at the British Telecom Higher Education Conference, November 1997:

> *"I have spent 18 months living "HE in the Learning Society" and promoting a concept which is of world-wide interest. Education has been my passion for 50 years, and to make a useful contribution to life, you need to get involved in education. To make the country more competitive, we need relevant and effective training, and for people to commit to lifetime learning. There is no future for the country in depending on the technology of today, we have to be looking 10 - 15 years into the future. Education and Training for life has to be accomplished because the game is changing so fast."* [10]

The move from state supported higher education to self-financed higher education has instilled the "customer" mentality into the student body, resulting in greater demand for value-for-money returns in their investment into universities' degree courses. The government responded by accepting that students should pay towards tuition and also announced that, as of September 1998, the current cost of living grant and loan scheme would be replaced with a single loan system. The tuition and cost of living loan would be paid back on an income dependent basis.

III. Traditional Engineering Degree Programmes

It is compulsory for U.K. children to start school at five years old and many start nursery schools (equivalent to kindergarten) at four years old. They go through 6 years of Primary

School, and are required to take the traditional 11+ examination, having acquired the Stages 1 and 2 of the National Curriculum. They then continue for Stages 3 and 4 of the National Curriculum, which will take another 5 years. After this they sit their General Certificate School Examination (GCSE) external examinations, and this is the dividing line between compulsory and tertiary education. Those who continue onto higher or tertiary education either enrol in a two year Advanced Level course or a two year Higher National Certificate (HNC)/Diploma (HND) course awarded by Business & Technology Education Council (BTEC), City & Guilds of London Institute (CGLI), Royal Society of Arts (RSA), etc. which are national recognised, external examining bodies. Those who are on the A-Level route have already studied for 13 years, having one extra year of school when compared with the American practice which is 12 years of schooling (6 years of primary, 3 years of junior high and 3 years of senior high). It means that a high school graduate with A-Level in the U.K. will reach the standards equivalent to the level of a freshman in U.S. colleges. For this reason, most U.K. university programmes, including engineering, are of three years duration (rather than four years as in the U.S.A.)

To prepare for traditional UK engineering programmes, students, having studied high school A-Level science-based subjects like Pure Mathematics, Applied Mathematics, Physics, Chemistry, etc. would then compete for a place in traditional engineering courses in universities such as Imperial College (IC), Birmingham University, University of Manchester Institute of Science and Technology (UMIST), etc., which have established strong courses for the education of future engineers. Traditional courses in engineering require a three year programme leading to a BEng.(Hons) degree in a chosen discipline, which is roughly equivalent to the top 50% of an U.S. graduating class, or having GPA of 3 or above. Such courses have to be accredited by U.K. professional institutions like the IEE, IMechE, etc. so that the graduates will be recognised in their partial fulfilment of the requirements to become a Chartered Engineer (equivalent to U.S. registered Professional Engineer) in the United Kingdom. For students taking an accredited course[12], there may be an option for taking a year out in industry where they will acquire practical and up-to-date skills in a chosen discipline. Such courses are commonly known as “thick sandwich” courses. In the future, it is likely to become the norm for an engineering graduate to go through a four-year programme before he or she lands his or her first job as a trainee engineer.

As far as the academic content of the engineering courses is concerned, students are provided with a rigid set of programmes within the major field of discipline. Common core subjects are sometimes taught collectively across the various engineering disciplines. Teaching normally occurs in small class sizes, usually under 50, and individual departments are responsible for teaching students registered in their chosen department. Computer programming courses are often taught in engineering departments rather than in specialised Computer Science departments. Languages taught have included Fortran, Basic, Pascal, etc. in the past, and are now mostly C, C++, and Java in the present. Microprocessor courses were very popular in the late 70s to early 80s, with a great demand from industry. However, software courses seem to have taken the top share of the computer curriculum in recent years. Perhaps the main area of recent changes in engineering education is American style modularization of courses and semesterization. A survey by the Committee of Vice-Chancellors and Principals (CVCP) in 1999 has indicated that the majority of the universities had moved to modularization of their courses.[3]

The major issues faced by higher education in the 1990s arise from a system that has become mass in its size but still remains elite in its values. The recent external changes of student numbers, delivery structures, finance and governance have not been matched by appropriate internal changes of values, purpose and activity. There is the "loss of the intimacy" stemming from the elite system of personal tutor, self-motivated learning, etc. in the past to the mass higher education in the present, forced by external political changes.[14] Such changes create an ambivalence in decision makers who still:

- define "A" levels as the major route into higher education and are against any reform;
- insist on a "gold" standard both for entry and exit qualifications against which all must be measured;
- rhetorically support broader access and greater diversity in the student population and yet condemn any sign of increase in non-completion rates;
- cut funding and yet expect personal service to students similar to that in decades gone by;
- in general wish their own experience of higher education in the pre- and post-Robbins elite period to be replicated in the mass era of the 1990s.

A prime example for such ambivalence is highlighted in the recent changes to the routes to registration of Chartered and Incorporated Engineers, which is the equivalent of professional engineers and assistant engineers. This will be discussed in greater detail in a later section.

IV. Current Enrolments in U.K. Engineering Courses [4,5]

Figure 1 shows all the recognised Universities, University Colleges and Higher Education Colleges in the United Kingdom, with data base last modified as of November 19th, 1999 hypertext-linked with the web-site address indicated below. For the engineering students of the nineties, there are a great variety of universities and courses to choose from[1]. In 1995, there were 2849 courses in Engineering, and about 20% of all the full-time-equivalent students took a course in engineering or courses relating to computing, information technology, etc. The following Table[6] illustrates the geographical breakdown of student intakes in the United Kingdom.

Region	Number of FTE Students enrolled in Engineering-related courses	Percentage of engineering students according to regional distribution (%)	Grand Total of FTE students taking degree courses
England	183096	71.5	1122648
Wales	28350	11.1	72411
Scotland	27337	10.7	128700
N. Ireland	5725	2.23	30978
UK Total	255794	100	1354739

Students are normally accepted into their chosen course via an examination route. The **U**niversities and **C**olleges **A**dmissions **S**ervice for UK (UCAS) [11] operates a national centralised collection and distribution of results for many U.K. and international qualifications, such as GCE A

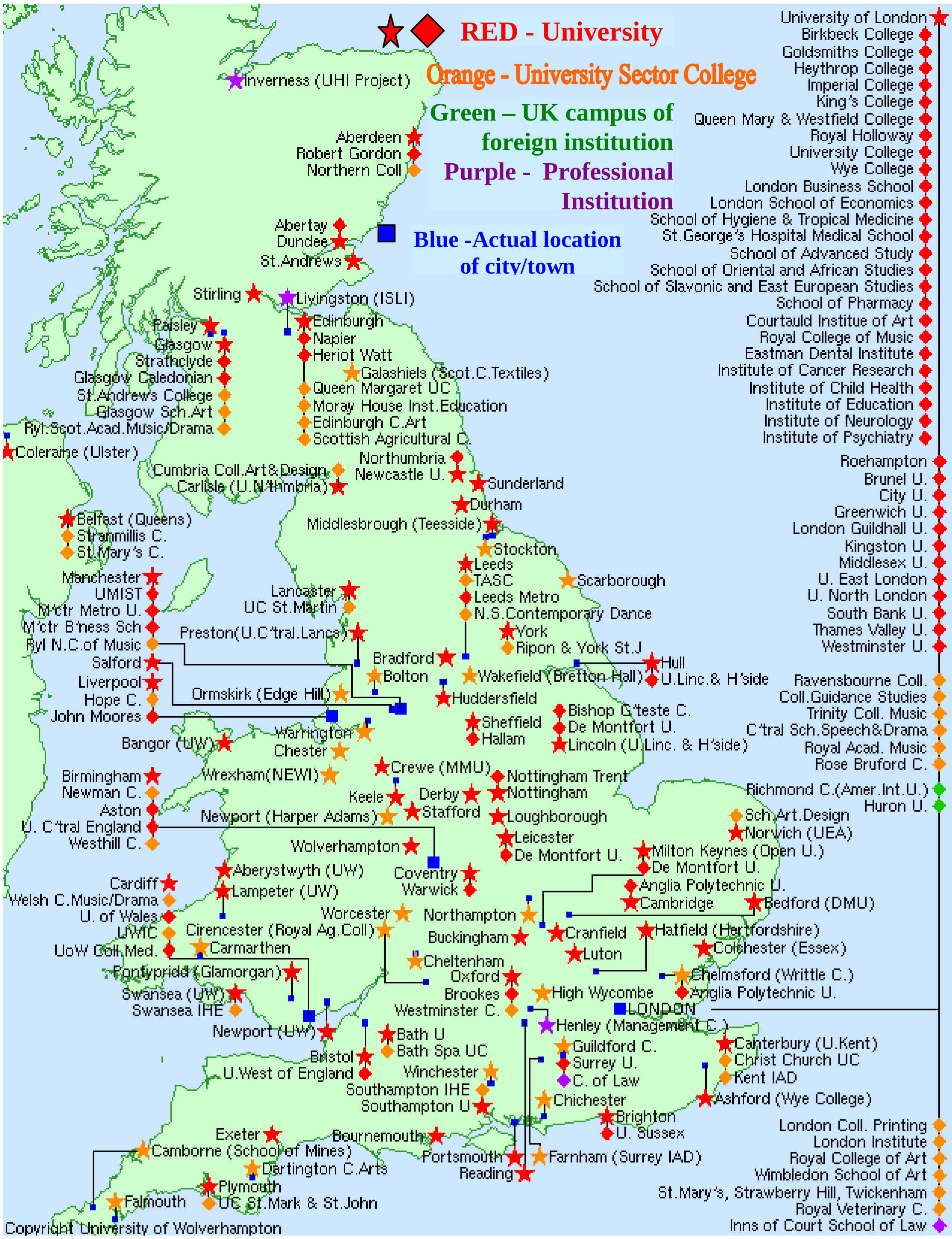

Fig. 1 Map of Universities and Further Education Colleges in UK [2]
[URL: http://www.scit.wlv.ac.uk/ukinfo/uk.map.html]

levels (including overseas A Levels), GCE AS, SQA qualifications, Irish Leaving Certificate, International Baccalaureate, Business and Technology Education Council's (BTEC) Higher National Certificate/Diploma (HNC/HND), Advanced **G**eneral **N**ational **V**ocational **Q**ualifications (GNVQ), and Advanced International Certificate of Education. The most common entrance qualification is the General Certificate of Education **A**dvanced **Level** (known colloquially as 'A-Level'), which is the equivalent of U.S. High School Graduation. Entry qualifications in the 1990s are much varied as compared with earlier entry requirements in the 1960s, and the percentage of eligible student intake has increased two fold compared with statistics in the 1960s[7].

V. Current Developments in UK Engineering Education: SARTOR '97

Recently the standards required for Corporate Membership (i.e. Professional Engineer level) of the engineering institutions (e.g. IEE[8], IMechE) and registration with the Engineering Council[9] have been radically revised. The new standards are set out in the 3rd Edition of the Engineering Council's publication **S**tandard **a**nd **R**outes **to R**egistration, better known as SARTOR '97. Trainees who have already commenced structured training before September 1999 will be able to apply for Chartered Engineer status under the SARTOR '90 regulations. The following Table summarises the major changes:

	SARTOR '90	SARTOR '97 (from 9.1.1999)
Stage 1	An IEE-accredited BEng of at least 2nd class Honours level, or equivalent.	An IEE-accredited 4-year MEng, or a BEng 2nd (Hons) + at least one further year of learning (matching section). [For students starting University in 1999]
Stage 2	Two or more years of Structured Training of which at least 6 months are normally gained after graduation. Alternatively, a longer period of Experience in lieu of training (EIL) of which at least 12 months has been gained after graduation.	A period of formative Professional Development, to acquire the Competence and Commitment appropriate to a Chartered Engineer.
Stage 3	At least 2 years of Responsible Experience gained after the completion of "structured training" or equivalent, and confirmed by "peer assessment" at the Professional Review Interview.	A "peer assessment" of experience and capability against the competence criteria, and test of personal commitment to professional conduct and development.

A major revision of the 1990 edition of SARTOR had become necessary, in the view of the Engineering Council, because of the changed national and international circumstances, including:

- Operation in a global market for goods and services, underlining the need for internationally recognised qualifications

- Changes in the school curricula in mathematics and other subjects relevant to the needs of engineering
- Change from a selective to a mass system of higher education and a consequent need for universities to provide courses of different type and levels
- Doubt about the equivalence of output standards from different universities
- The increasing use of “occupational standards” by employers

To ensure UK engineering qualifications continue to compare with the best internationally, major changes need to be made to the educational base and the initial professional development leading to the professional review of future U.K. engineers.

VI. Some Implications of SARTOR ’97 for U.K. Engineering Education

Benchmark routes towards Chartered Engineer (CEng) status for 4-year degree and 3-year degree candidates, are shown in Figure 2. Major forth-coming changes to the existing engineering education and professional development are summarised as follows:

The educational base

- Four years academic study for Chartered Engineers instead of three. Such requirements can be met by a 4-year accredited MEng degree or equally by a 3-year accredited BEng(Hons) degree plus a “Matching Section”.
- Three years academic study for Incorporated Engineers instead of two. Such requirement can be met by a 3-year accredited IEng degree or equally by a 2-year Higher National Diploma (HND) plus a “Matching Section”. There is no equivalent of an IEng degree in the USA, but it is similar to associate degree level, rather than US graduate level.
- Introduction of entry standards into criteria for accreditation to ensure a cohort of sufficient intellectual capability to support a high standard of course contents. Such requirements are being “ramped-in” over four years from September 1999 onwards.

Professional Development & Review

- Expansion of Initial Professional Development (IPD) to improve the acquisition and development of the skills, specialist knowledge and competence needed to practice in a specific area of engineering. Such on-going development would require that the IPD should be recorded by the trainee and certified by an approved supervisor or mentor and it should be subjected to external assessment.
- The competence achieved through IPD is demonstrated and assessed in a more stringent Professional Review process, the final step before registration. The assessment will be based on evidence of professional competence set against agreed criteria for the type of work. This will require a written report from all candidates and an in-depth interview by two suitably qualified Chartered or Incorporated Engineers, for CEng or IEng candidates.

- The Professional Review will require the candidate to demonstrate a commitment to Continuing Professional Development (CPD) and to the Code of Conduct and relevant Code of Practice.

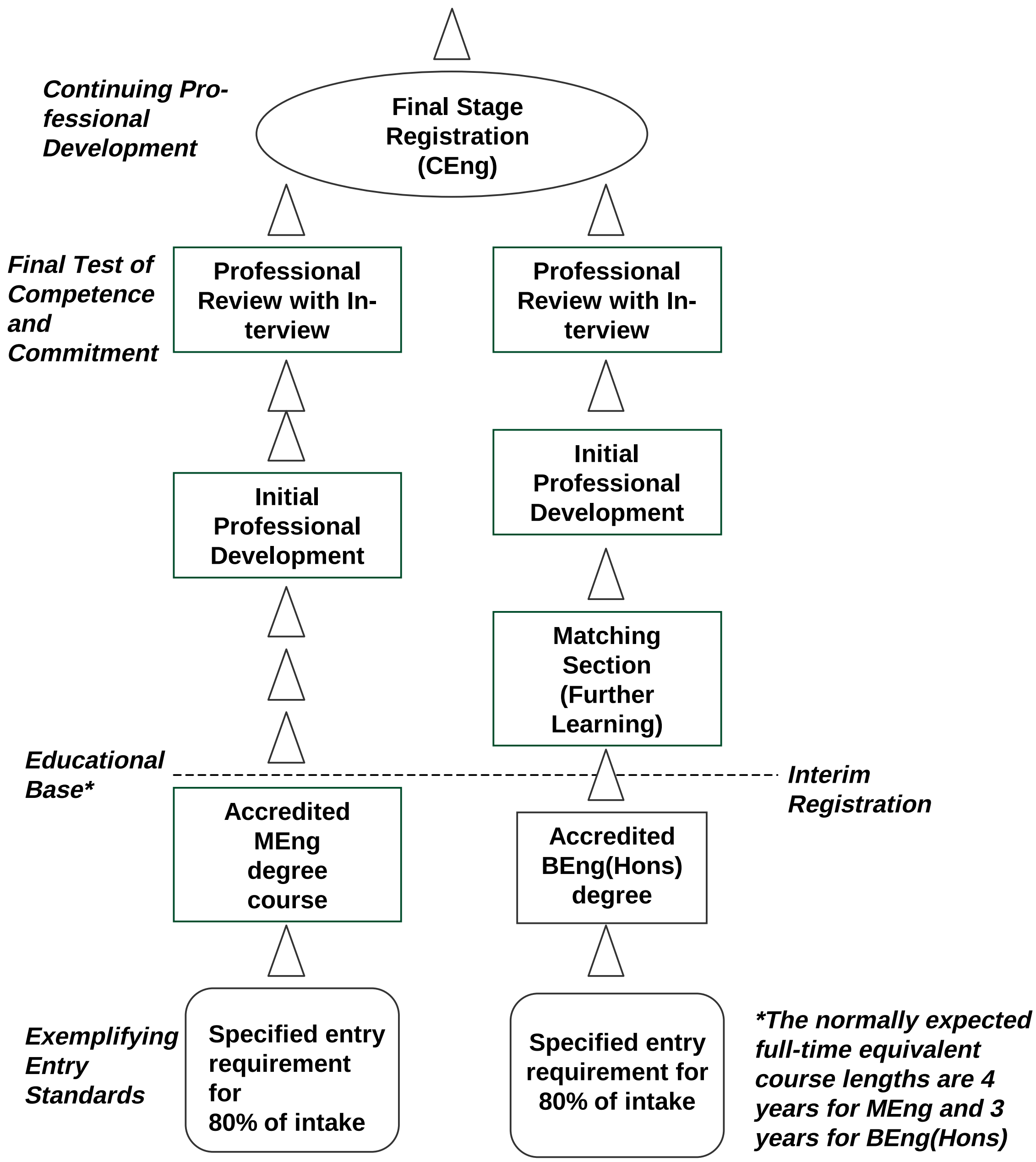

Fig. 2 Benchmark Routes for Chartered Engineer

VII. Conclusions

What are the implications of SARTOR on the recruitment and implementation of undergraduate and graduate courses in the engineering disciplines?

In the U.K., in the period 1993-97, there was an increase of total acceptance onto all degree programmes of 45,000 students. But, in the same period, there was a reduction of acceptances onto engineering degree programmes of 4,500 students.[11]

In the foreseeable future, there will be fewer students taking CEng courses, and more students taking the lower level IEng courses. A more alarming trend is that more students are taking non-accredited courses as offered by new universities. In order to "attract" potential customers, universities, old or new, will have an opportunity to design and market a much wider range of engineering courses and modules, and potentially provide lucrative and valuable interaction with industry in course design and provision. However, the major challenge remains daunting. Recruitment of "good" students for CEng courses will be very competitive in view of the lower student intake. Fewer students taking CEng courses will require the development of new IEng courses and non-accredited courses in order for universities to economically "balance" the books, borrowing a phrase from the accountants. This "rule-by-accountant" practice could seriously affect the research culture within the Engineering departments, as traditionally the intake of graduate students depends mainly on the intake of undergraduate students, apart from overseas recruitments. All in all, the recent developments will provide many open opportunities for universities who wish to widen access to Higher Education with the introduction of IEng and non-accredited courses. However, major challenges to the universities will remain as they strive to strike a balance between the quality of research activities and the academic profile of undergraduate and post-graduate courses.

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