Curriculum Diversity in a Common First Year

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Abstract: *This paper reports on the curriculum structure, underlying rationale and successes of the flexible 'common' first year of the Bachelor of Engineering at the University of Queensland. Pressures to accommodate both increasing depth and breadth of study, while at the same time increasing flexibility and choice to suit an increasingly diverse student cohort being educated for increasingly diverse employment opportunities and careers are discussed.*

Keywords: *Common first year, diversity, early specialisation, curriculum, flexibility*

Introduction

Historically, the BE program at the University of Queensland (UQ) has had a common first year. We have for many years admitted approximately 500 engineering students, predominantly high school leavers drawn from schools throughout Queensland and Northern New South Wales, under a single quota into the common first year of study. This is intended to provide a broad yet strongly relevant base leading into further study in all divisions of engineering offered at the University. There is currently a choice of 12 distinct disciplines (and one sub-discipline) of engineering at UQ. Despite this large range of offerings the common first year was considered to be advantageous for the following reasons.

Students leaving high school in Queensland are relatively young at an average age of $17^1/_2$. They are required to complete only 12 compulsory years of schooling whereas their counterparts in southern states do 13 years. They often have ill conceived and poorly defined notions of engineering, and are unsure of whether engineering is the right career choice. Many are equally confused about the distinguishing characteristics of the different engineering disciplines available for study and the associated employment and career opportunities. The common first year gives these students an opportunity to develop their understanding of engineering, appreciate its breadth, and explore the nature of its constituent disciplines before making a choice of one particular discipline. Anecdotal evidence over many years indicates that students considered this to be a positive influence on their choice of engineering at UQ.

From a University perspective the admission of engineering students under a single quota to a common first year also has advantages. Engineering is promoted and marketed to the schools' community as the career option, rather than a fragmented approach by individual engineering disciplines, each competing for a share of the intake and EFTSU. It is advantageous, we believe, to try to describe and market a unique and distinguishing set of characteristics that identifies and differentiates engineers, irrespective of the discipline to which they belong. Examples of how these characteristics translate into the various disciplines is always of interest to the prospective student, but is there to support the message about the overarching identity of the engineering profession as a collective and in its entirety.

However, the very breadth of engineering is an issue when designing a common first year to suit all constituents. The diverging nature of engineering is in part due to emergent disciplines such as computer systems engineering, and biomedical engineering which do not rely solely on the traditional fundamentals of physics, maths and chemistry around which the common first year was routinely built. The dynamic growth in the cognate sciences underpinning these emergent fields e.g. information technology, biology must somehow be incorporated into an already overcrowded curriculum. For example, chemical engineering undergraduate programs were formerly based on the sciences of chemistry, mathematics and physics. The growing field of bioengineering at the interface between chemical engineering and biology, means many chemical engineering programs now include a compulsory unit of biology. Figure 1 shows the range of engineering disciplines available in undergraduate programs at UQ and their cognate sciences. Mathematics is not identified on the diagram as it is considered to be equally important and universal across all engineering fields.

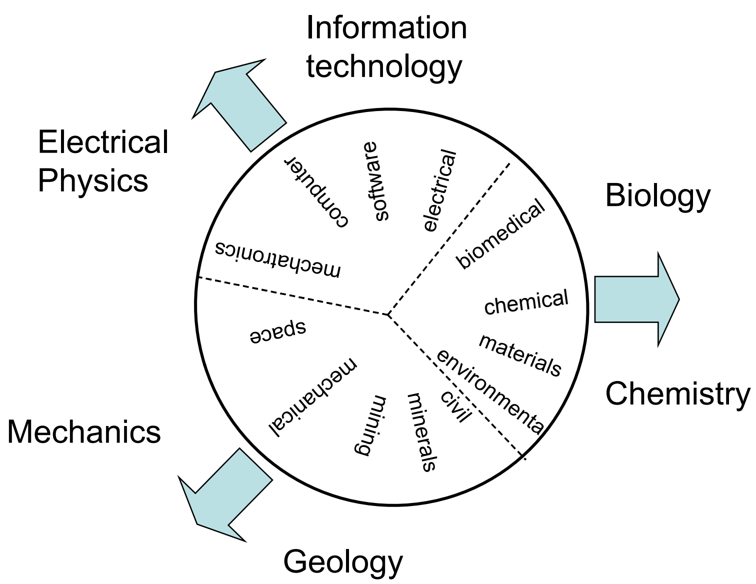

Figure 1: Growth in Engineering Disciplines & Cognate Sciences

Furthermore, there is a blurring of the boundaries between science and engineering, arising in part because engineers now work across multiple scales varying by many orders of magnitude with exciting developments occurring at the extremes of scale. Examples are nanotechnology and chemical product design, primarily concerned with what happens at a molecular scale, whereas environmental modelling operates on a regional, national, even a global scale. There is also increasing differentiation within the profession with regard to engineering roles such as design, systems engineering, and the pervasive use of information technology in engineering. The current debate within the professional and public press (Boshier, 2003) revolving around Rosalind Williams' *Retooling: A Historian Confronts Technological Change* (2002) is evidence of the continuing expansion of engineering and its 'identity crisis'.

There is also increasing diversity within the student body. Students enter from increasingly different backgrounds. Even though our first year intake is still predominantly school leavers, they have a wider range of abilities, educational experiences and interests than ever before. For instance, several years ago the entry requirement for compulsory advanced mathematics was abolished, and now approximately one third of our cohort enters with only one high school mathematics subject, Maths B. Similarly they bring a huge range of study interests, ambitions and career aspirations. It is no longer sufficient to offer inflexible degree programs with little or no choice, and that lead only to the development of depth in one chosen area of engineering e.g. civil engineering.

Students are now aware that engineers are increasingly engaged in complex and multidisciplinary work. There is a need for those with both highly specialised knowledge and narrowly focused skills sets, and for those with a broader skills set. Engineering students want to combine engineering not only with science, but also with business management, law, foreign languages, psychology and many others. The proliferation of and demand for dual degrees at Universities across Australia is testimony to the growing student recognition of the value of a broader education and multiple qualifications, as preparation for the complexity and multi-disciplinary demands of the modern work place. Thus there is now a balance to be reached between the demands for depth and breadth in the education of engineers in undergraduate programs.

In response to the growing demands arising from the increasing diversity within the profession and students, the common first year at UQ was recently reviewed with the critical issue seen as the depth versus breadth dilemma. What is an appropriate balance between depth and breadth within a core engineering curriculum? And how can we accommodate flexibility to give students choices with respect to adding further depth or breadth to their studies?

It is a tall order to design a first year program that caters for the interests of 500 students in disciplines that range broadly from biomedical to software engineering. Of the students entering first year from high school, about half of these know, or think they know, which engineering specialisation they wish to pursue, and want to feel that they are getting on with it. This is particularly true in the areas of Computer Systems, Electrical, and Software Engineering. The other half are undecided and value a year of broad exposure to available specialisations before deciding on one in Year 2. Approximately ten percent of the cohort also identify at the start of their studies their intention to take out a second degree, the most popular being business management, commerce and arts. Year 1 is now designed to cater for all groups by providing for 'direct entry' into a specialisation, or enrolment in one of two general plans that keep a number of options open. Dual degrees are available in most, but not all direct entry, and both general plans.

The General Plans

Experience indicates that the undecided students fall mainly into two groups, those deliberating among Computer Systems, Electrical, and Software Engineering, and those deliberating among the other specialisations. Therefore two general plans are designed with these two groups in mind. Students who wish to defer some choice of specialisation to their second year are advised to enter one of the two general plans shown below in Table 1

General Engineering Plan A Leads to Year 2 specialisation in	**General Engineering Plan B** Leads to Year 2 specialisation in
Chemical	Computer Systems
Civil	Electrical
Environmental	Software
Materials	
Mechanical	
Minerals Process	
Mining	
Early Specialisation in mandatory for	
Mechatronic Engineering	
Mechanical & Space Engineering	
Early specialisation is optional for all general plan disciplines	

Table 1: First year BE enrolment options

Details of the structure of the general plans is shown below

Compulsory Plans A & B	**General Plan A Compulsory**	**General Plan B Compulsory**	**Electives**
Introduction to Professional Engineering Mathematical Foundations* Calculus & Linear Algebra I Multivariate Calculus & Ordinary Differential Equations * compulsory for students without Senior Maths C	Applied Mechanics Physics & Engineering of Materials Applied Chemistry for Engineers Engineering Thermodynamics	Introduction to Computer Systems Introduction to Software Engineering Introduction to Electrical Engineering	Genetics & Evolution Molecular & Microbial Biology Human Biology Ecology & Environment Sustainable Development of Resources Earth Processes & Geological Materials for Engineers Electromagnetism, Optics, Relativity & Quantum Physics I Physical Basis of Biological Systems Physical Principles of High Technology

Table 2: Curriculum Structure of the Common First Year

All students irrespective of which general Plan or 'direct entry' specialisation they choose, must complete the compulsory courses shown in the first column in Table 2. Depending on their entry level mathematics, this includes 2 or 3 mathematics courses. The other compulsory course for all first year engineering students is Introduction to Professional Engineering. This course targets development of the broader engineering graduate attributes and also introduces students to the breadth of engineering practice and issues. To realise the learning objectives, the course consists of team project work and a series of keynote lectures addressing a broad range of engineering issues. However most of the student activity and assessment is built around the substantial team project. Trendy topics are chosen and framed to simulate a real life engineering project and we try to match students with their preferred projects. However the processes associated with development of broad graduate attributes and skills, such as team work, communication and project management, are the main learning objective and are common across all 5 projects. Project plans, project management logs, written team reports and oral presentations are all incorporated into the team project component of the course and are assessed. The projects run across the entire semester and are therefore a substantial component of the students' first semester workload.

The number of electives that can be chosen depends on the entry level mathematics and which general plan is chosen. Some students have no electives, eg those without advanced high school maths and entering General Plan A. Students with advanced high school maths have at least one elective in first year irrespective of which general plan they enter.

Students who are confident with a choice of specialisation may elect to follow a 'direct entry' or 'early specialisation' plan that opens up a greater choice of electives within first year. For example, an 'early specialisation' plan for chemical engineering nominates only chemistry and thermodynamics from the General Plan A list as compulsory. 'Early Specialisation' chemical engineering students interested in biomedical engineering or biotechnology can choose biology electives in place of the other two compulsory Plan A courses, Applied Mechanics and Materials. 'Early specialisation' civil engineering students need only Applied Mechanics and Materials. Electives for civil engineers can be Geology, and Sustainable Development of Resources. Of course, any of the compulsory courses from either of the General Plans are also legitimate 'early specialsiation' electives.

Dual degrees students wishing to follow a General Plan can also be accommodated. Dual degree students undertaking Arts or Business as their second degree would normally defer two of the first year engineering courses to start the second degree. These students require careful academic advising on deferring engineering courses according to likely or unlikely choices of discipline.

Discussion

The General Plans and 'Direct Entry' arrangement are successful in managing the conflicting students demands for 'getting on with what they want to do within a chosen specialisation' and deferring choice of specialisation. Enrolment data indicates that approximately half of our first year students nominate an early specialisation, confirming our earlier conviction that about half of the intake have made a choice of engineering discipline before they arrive at University. Complaints from this subset of the first year cohort about the frustrations of being in a broad based first year have now disappeared. Of the remaining half that follow one of the general plans, most wait until their second year of study to nominate their chosen specialisation, thereby taking full advantage of the extra year.

The growth of the engineering and science interfaces and the broadening of the science electives available in first year engineering, particularly the inclusion of biology, open up new pathways into engineering from the sciences. There has been growing interest in engineering from students with a biology/biotechnology background. This includes students who have not or would not have entered engineering through the usual matriculation from school. The development of new dual degrees such as the Bachelor of Engineering/Master of Biomedical Engineering, and Bachelor of Chemical Engineering/ Bachelor of Biotechnology has attracted strong interest from such students. And there is greater representation of engineering courses in associated science degrees. This contributes to the continuing diversification of our student body and ultimately the engineering profession at large. This diversification is a desirable long term outcome for the profession and was identified as a significant issue for engineering educators in the most recent Australian review of Engineering Education (IEAust, 1996)

The course, Introduction to Professional Engineering, continues to be a very successful part of the restructured 'common' first year. The use of a project-based course as a vehicle to begin developing generic graduate attributes in an engineering context has proved effective. Students like being given a choice of project, they enjoy the project work, and the team work is a useful way of establishing collaborative study groups within a large cohort just beginning their University studies. In the recent IEAust accreditation visit to the University of Queensland, this course received plaudits from both the student body and the accreditation review panel who commended it as an exemplar for further development of project centred learning in later years and across all engineering disciplines (IEAust, 2002).

We believe our restructured 'common' year, with the practice course, Introduction to Professional Engineering, and its general plans, or a 'direct entry' option represents an excellent balance between the demands for early and deferred specialisation. It combines flexibility of choice and recognition of the expanding scientific base of engineering practice with a common core of study, including a broad based introduction to professional engineering that exposes students to the breadth of engineering. The curriculum is structured to accommodate both the student who is interested in depth within engineering study, and the student interested in broadening studies outside a conventional engineering program.

We believe this is an excellent model for encouraging and facilitating diversity while retaining most of the advantages of a common first year of engineering studies. It appears to have worked well for all stakeholders since its introduction at the University of Queensland three years ago. And as a final accolade, there have been recent expressions of interest in this approach to first year from engineering schools of other Group of 8 Universities in Australia, thus validating our confidence in the strengths and attractiveness of our current flexible 'common' first year.

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