The 'Melbourne Model' and new Engineering Degrees at the University of Melbourne in 2008

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Abstract: *The University of Melbourne (UOM) is currently Australia's leading research university and the Faculty of Engineering at UoM is ranked number one in Australia (THES 2007). It is a large university (with about 42,000 students) and comprehensive, with all disciplines represented--engineering has about 4,300 students. The UoM has adopted a new strategic plan, called "Growing Esteem". A key strand of the strategic plan is the group of landmark educational reforms known collectively as the 'Melbourne Model'. These reforms are designed to create an outstanding and distinctive 'Melbourne Experience' for all students. In moving to this new model, the University is responding to the challenges of today's changing environment as well as aligning itself with the best of European and Asian practice and North American traditions. This paper contains a brief overview of the Melbourne Model, describes the motivations for the introduction of an accredited five year engineering degree, as well as describing the structure of the five year engineering degrees at The University of Melbourne. The new five year engineering degrees commence in 2008.*

Introduction

The University of Melbourne's strategic direction is outlined in *Growing Esteem: The University of Melbourne Strategic Plan 2006* (UniMelb 2007). A key strand of the strategy is the development and implementation of the 'Melbourne Model' (MM) (UniMelb 2007). As described in the strategic plan, the Melbourne Model is to be distinguished by "an exciting and far-reaching curriculum reform designed to create an outstanding and distinctive 'Melbourne Experience' for undergraduate and postgraduate students." An enormous amount of planning has gone into the development of the MM, and included a comprehensive report from the University Curriculum Commission outlining the principles and proposed structures for the MM. This plan was approved by Academic Board in 2006.

The degree programs in the Melbourne Model are sequentially structured as follows:

- A three-year undergraduate degree (the three year 'new generation degrees' are 'stand-alone' degrees, in the sense that on completion graduates may seek employment or pursue further study);
- If further study is chosen, the undergraduate degree may be followed by either further scholarship (e.g. masters by research) or professional training (e.g. a two year (or possibly longer) professionally accredited program);
- If further study is chosen by the student, the professional master's degree may in turn be followed by a three-year doctoral program (i.e. either a PhD by research or, in some Faculties, professional doctorates).

The degree structure outlined above is referred to as a 3+2+3 model. This is the foundation degree structure known as 'Bologna Model', currently being introduced in Europe (though variations on the 3+2+3 degree plan are both allowed and common in Europe).

In the Melbourne Model, there are six new generation undergraduate degrees, four of them with engineering pathways (Figure 1):

1. B Arts (including humanities and the social sciences);
2. B Science (including a pathway to an accredited +2 engineering masters degree),
3. B Biomedicine (including a pathway to an accredited +2 engineering masters degree),
4. B Environment (including a pathway to an accredited +2 engineering masters degree),
5. B Commerce (including a (breadth) pathway to an accredited +2 engineering masters degree),
6. B Music.

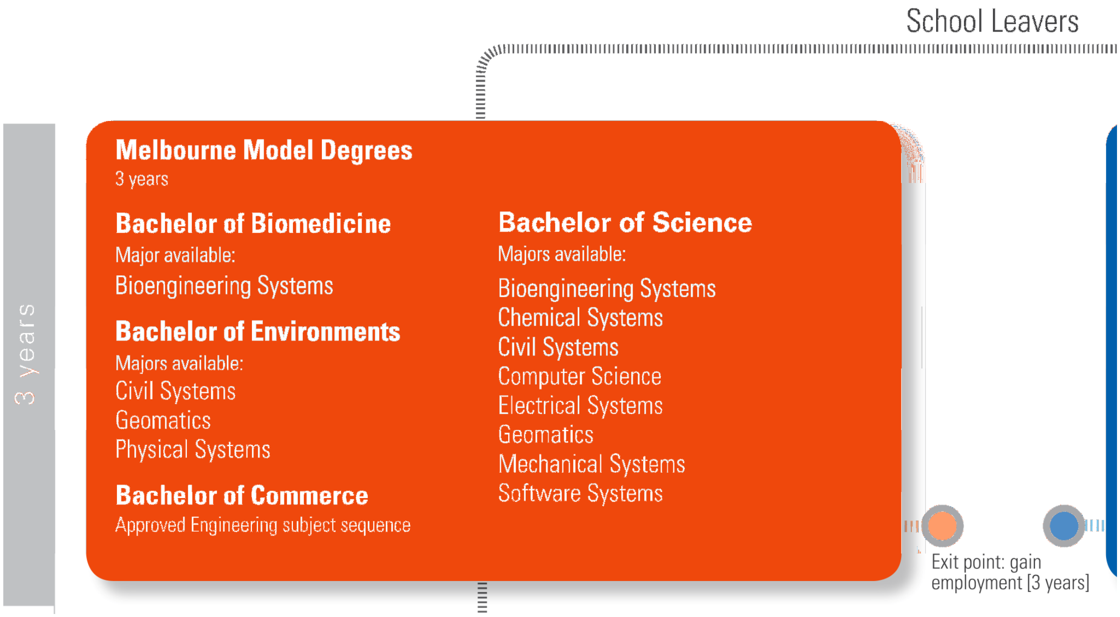

Figure 1 - Engineering majors in New Generation Degrees

The 'new generation undergraduate degrees' all have the consistent aims and benefits of:

- An enriched 'Melbourne Experience' through distinctive undergraduate courses which offer pathways into professional graduate programs, but which also stand alone as strong degrees;
- A strong discipline-based education, including an introduction to research.
- Closer alignment of course structures with desired graduate attribute outcomes
- An improved classroom experience, including smaller classes.
- Stronger likelihood of well-rounded and motivated graduate students.
- Degrees developing interdisciplinary skills and preparing graduates for a variety of postgraduate programs, as well as employment in diverse workplaces;
- The development of well-rounded and motivated students;
- Broader access for students especially those from disadvantaged backgrounds; and
- A strengthening of international recognition of degrees at the UoM.

The core principles within the Melbourne Model are:

- Flexible student pathways, so that students may make more informed career choices;
- Development of a 'breadth of knowledge' across disciplines, while retaining adequate preparation for professional programs.
- A capstone subject, designed to draw together the various strands present in the degree.
- A stronger shared cohort experience, including a greater sense of university community;
- Creating global citizens; students will be encouraged to undertake part of their degree in another country.

Indeed, flexibility, meaning a student retaining as much choice as possible for as long as possible, is a key aim of the MM. This approach is clearly 'empowering' to students, allowing students to actively choose their career in a sequenced way at each stage of their education, with their choices informed by previous exposure to different disciplines, as well as their own individual experiences as they mature. This is in contrast to current professional degree programs offered at the UoM (and in most engineering schools), where students typically choose vocationally oriented courses from the beginning of their study. In some sense, the UoM from 2008 will become a 'marketplace of educational opportunities' for students. This will clearly contribute to a distinctive 'Melbourne Experience'. This is also consistent with the views of Lord Alec Broers (engineer and former Vice Chancellor of Cambridge University) delivered the third annual UK Education Policy Institute lecture (Nov 2005):

> *I believe that what we need from our universities first and foremost is the provision for young people of an adequate broad knowledge base, together with modern analytic and communication skills—if you like, the modern version of Newman's rudiments of intellectual enquiry. Many of our undergraduate courses have become too narrow and over-specialised, and do not equip the young with the flexible intellects that will be able to adapt to changing circumstances. An undergraduate degree should cover the fundamentals of coherent range of subjects. Students need expert advice in choosing their subjects, but the ultimate choice should be their own.*

Under the Melbourne Model, all students will undertake a major as part of their new generation degree. Majors will comprise a sequence of one or two subjects in the first year, three subjects in the second year and four in third year – the equivalent of approximately one third of an undergraduate program. Coupled with complementary subjects in the degree program, this ensures that all students have the necessary depth for employment or graduate programs. In addition, one quarter of the new generation undergraduate degree will include subjects in another discipline area, ensuring that students have exposure to alternative 'modes of enquiry' or 'ways of knowing'. This clearly contains the elements of a 'liberal education', which is favoured in many US Universities.

Towards the end of the new generation degree, students will undertake a 'capstone' activity designed to draw together the various strands of their undergraduate education, and prepare them for life as a graduate. Typically, capstone activities will incorporate a research project or examination which encourages students to consider the broad context of their discipline. The scope of these subjects will vary, from synthesising and analysing material in the major to developing specialist skills relevant to further study or workplace applications.

Many students today have complicated timetables that lead to them being with a different group of fellow students for many subjects. This decreases the opportunity to develop *learning communities*. By reducing the number of degrees, and by removing parallel "double degrees", there is a much greater opportunity for students to form close and sustaining friendships and study groups. This ensures a richer *cohort experience.*

As part of creating aware students prepared for the modern workforce, greater emphasis is placed on knowledge transfer, cross-border collaborations and global partnerships, which in turn offer more opportunities for overseas studies and international exchange.

Finally and importantly, the Graduate Attributes for The University of Melbourne students have been carefully reconsidered, and a new set of desirable graduate attributes defined. It is expected that The Melbourne Experience enables our graduates to become:

- Academically excellent:
  - have a strong sense of intellectual integrity and the ethics of scholarship
  - have in-depth knowledge of their specialist discipline(s)
  - reach a high level of achievement in writing, generic research activities, problem-solving and communication
  - be critical and creative thinkers, with an aptitude for continued self-directed learning
  - be adept at learning in a range of ways, including through information and communication technologies
- Knowledgeable across disciplines:

- examine critically, synthesise and evaluate knowledge across a broad range of disciplines
- expand their analytical and cognitive skills through learning experiences in diverse subjects
- have the capacity to participate fully in collaborative learning and to confront unfamiliar problems
- have a set of flexible and transferable skills for different types of employment

- Leaders in communities:
  - initiate and implement constructive change in their communities, including professions and workplaces
  - have excellent interpersonal and decision-making skills, including an awareness of personal strengths and limitations
  - mentor future generations of learners
  - engage in meaningful public discourse, with a profound awareness of community needs

- Attuned to cultural diversity:
  - value different cultures
  - be well-informed citizens able to contribute to their communities wherever they choose to live and work
  - have an understanding of the social and cultural diversity in our community
  - respect indigenous knowledge, cultures and values

- Active global citizens:
  - accept social and civic responsibilities
  - be advocates for improving the sustainability of the environment
  - have a broad global understanding, with a high regard for human rights, equity and ethics

Engineering Education

Internationally, there has also been vigorous debate concerning engineering education as it responds to a number of powerful worldwide trends including:

- the decreasing numbers of students choosing engineering (as well as decreasing numbers choosing maths and basic science subjects like physics, chemistry, biology and geology), particularly in affluent countries including those in North America, Europe and Australia;
- the large numbers of engineers being produced in developing countries like China, India, Taiwan, Korea etc;
- the globalization of economies and workforces, leading to extraordinary competitive pressures and rapid change;
- information technologies creating better informed markets and facilitating practical and meaningful international collaborations and partnerships, in business, education and research;
- increasing world population and increasing living standards making sustainability a central international issue.

Given these trends, it has been clear for some time that engineering education needs to change to meet the changing expectations for graduating students. The recent history of engineering education reform up to 2003 is well summarized in a series of papers by Frank Splitt, Prof of Telecommunications at North-Western University (Splitt 2002). Splitt emphasizes the need for engineering education itself to be seen as a critically important activity within universities, as important as research. He argues that for the status of engineering education in universities to improve, it is vital that bodies like the National Academy of Engineering give proper recognition to the role of engineering education and to the importance of engineering educators.

The National Academy of Engineering has responded positively to these urgings, and recently published two key documents, *The Engineer of 2020* (National Academy of Engineering 2004), and *Educating the Engineer of 2020* (National Academy of Engineering 2005). The first document describes various scenarios, and defines the graduate attributes necessary for the Engineer of 2020. The second document seeks to push along change in engineering education to get better alignment between engineering curricula and their capacity for developing the graduate attributes deemed desirable.

This has been received positively by the many Engineering schools within North America, with a group of universities attempting to implement recommendations through course revisions. Engineering Societies in North America have also responded positively. For example, the American Society of Civil Engineers (ASCE) recently completed an exhaustive five year process to arrive at the so-called 'Body of Knowledge' (BOK) for Civil Engineers in the 21st century (ASCE 2004). A second draft of the BOK document is to be completed by early 2008. It is noted in passing that the ASCE also recently passed a resolution to move to a Master's degree as the first professional engineering qualification (by 2020), rather than the traditional four year baccalaureate degree as the first professional engineering qualification. At the present time, the ASCE is setting up an 'implementation committee' to help educational institutions craft curricula that align with the BOK.

In addition to the activity of various academies and professional societies, individuals and groups have recognized the need to reform engineering education, and bring it up to date with modern engineering research and practice. One good example is provided by the initiative of Prof Robert Armstrong, Head of Department of Chemical Engineering at MIT. After posting an open letter on the MIT website about four years ago, some 50 universities and 15 companies agreed to a series of workshops that have culminated in a series of recommendations on how chemical engineering education should be changed to reflect contemporary knowledge, challenges and practice (Armstrong 2005). A further vision of engineering education, one that aligns with engineering degrees within the Melbourne Model, has been recently proposed by Prof Judson King, a chemical engineer and Director of the Centre for Studies in Higher Education at UC Berkeley (King 2006). In his paper, 'Engineers should have a college education', King says:

> *Many societal trends and needs call for engineers to broaden their outlooks, have more flexible career options, and work closely and effectively with persons of quite different backgrounds. Yet the education and general orientation of engineers have been directed inward toward the profession, rather than outward toward the rest of society and the world. Engineering education should change to create a broader outlook and understanding in graduates and thereby engender capabilities for linkages and more likelihood of advancement into management and/or movement into other areas. The appropriate steps include moving the accredited professional engineering degree to the master's level and building upon a liberal education bachelor's degree that is analogous to pre-medical education.*

In a provocative article titled 'Education for the Profession Formerly Known as Engineering' (Williams 2003), Rosalind Williams (Director of the MIT Program in Science and Technology and Society) explains the effects of the above-mentioned worldwide trends on engineering in this way. Williams contends that engineering is undergoing an identity crisis, with its dominant mission no longer being the conquest of nature, but the creation and management of a self-made habitat. One side of engineering diffuses into the new world of biology, while the other diffuses into the ethereal world of cyberspace. While biology and communication technologies are making the boundary between science and engineering more poorly defined, both are part of an 'engineering-science establishment' that has developed over the last few decades. This culture is centred on fundamental research.

In order to recapture the 'essence of engineering', there is a strong movement back towards 'real practice'. One group advocates renewed emphasis on design and making things (CDIO 2007) (and identifies with entrepreneurs), while another group advocates the new emphasis on large technological systems (and identifies with managers, policy and its impact on society). Engineers now collaborate with all kinds of professionals, including scientists, lawyers, economists, and managers, to name a few. A constant concern of Faculty at MIT is whether to hire these people and have them on staff, or to have them as collaborators. Engineering is becoming a Profession of Everything, which shades into science, arts and management. As identified in the *The Engineer of 2020* (National Academy of Engineering 2004), for this reason engineering has the potential to become the 'liberal arts education' of the 21st century. As a consequence, engineering education keeps getting pulled in different directions—towards science, towards management, towards design, towards policy and social science—and this all adds to the curricular log-jam.

Williams suggests that many fewer students today want to commit themselves to an educational track that is nearly all consuming. Students want to receive a broader education, and are doing this broadening and mixing on their own (witness the growth in parallel ‘double-degrees’ in Australia). But in many cases they are trying to pour new educational wine into old institutional containers. Students are looking for an engineering education that is more socially aware in a pragmatic sense, as they need to know how society works, not just how to be socially responsible. Williams argues that the segregation of engineering education served its purpose many decades ago, but now this segregation defeats the purpose of engineering education and higher education today, at once marginalizing engineering and depriving the rest of higher education of its benefits. Williams believes that the convergence of technological and liberal-arts higher education is a deep, long-term and irreversible trend. Students need to be prepared for life in a world where technology, scientific, humanistic and social issues are all brought together.

Set against this view is the absolute need for engineers to produce safe and reliable solutions to society’s technology needs, ensuring things and processes conform to exacting design specifications. Such is the primacy of this need, performance specifications and design methods are codified both in Standards (e.g. codes of practice in Australia developed through Standards Australia, and internationally through the International Standards Organization (ISO)), but also codified through strict educational requirements needed to become a Professional Engineer. This accreditation is usually managed by professional engineering bodies (e.g. in Australia the primary accreditation for engineers is Engineers Australia, though several other accreditation bodies are important to Engineering (e.g. Surveyors Registration Board, Australian Computer Society, Institution of Chemical Engineers (UK), etc)). This primary need for a high level of technical expertise is recognized internationally, with professional engineering societies mutually recognizing each others professional qualifications through the ‘Washington Accord’ (International Engineering Alliance 2007). Professional qualifications obtained in any one of the signatory countries are automatically recognized in all signatory countries. In most countries, this recognition is necessary for practice as a Professional Engineer. So graduates that are to have an ‘international outlook’ and to work professionally overseas, need to graduate from an accredited degree program, accredited by an authority that is recognized in the Washington Accord.

As identified by Frank Splitt in his paper ‘The Challenge to Change: On realizing the Paradigm for Engineering Education’, the danger of maintaining only a technical focus is ‘The perpetuation of the old paradigm for engineering schools will all but assure minor roles for engineers in the future, as well as difficulty in adapting to the exigencies of a fast paced global marketplace.’

As more engineers are produced in developing countries, many technological skills will simply become commodities, meaning that technological skills and knowledge becomes standardized, and will be treated like any other commodity that is traded in an international marketplace. It makes no difference if an engineering design is produced in Australia, India or Mexico. It is expected that the effective operation of this ‘engineering skills marketplace’ will drive down the relative value of technical expertise, and so in the future lead to lower relative salaries for engineers with purely technical skills, as much of this work is outsourced to India and China (Freidman 2006).

A further educational challenge is the changing preparedness of students for study at university. Whereas a generation ago, prerequisites for engineering included two maths, physics and chemistry, the requirements now are more commonly one maths and one science. Universities have made this change to try to enlarge the pool of potential applicants in engineering. A consequence is the need for more flexible first year structures that allow students to take their missing maths and science, while allowing those with two maths and sciences to proceed directly into more advanced studies. All these considerations lead to the need for a more broadly-based curriculum that also allows students the flexibility to explore their interests. The Melbourne Model breadth as well as flexibility, as described in the following section.

Program structures

The major route for engineering students will be through the Bachelor of Science, Figure 2. Note that the first degree (years 1-3) is made up of 50% engineering, 25% complementary science and 25% breadth. This provides a broad foundation for further study. For example, a student may graduate with studies in engineering (9 units), mathematics (9 units) and commerce (6 units). Another option might be engineering (9 units), mathematics (3 units), biology (6 units) and a language (6 units).

The Master's degree contains a further 14 units of engineering, with the two additional units available to provide either catch-up for students who have entered without completing a full quota of undergraduate subjects or for professional enrichment. Either way, these are "approved electives".

Year 1	Engineering	Mathematics	Science	Breadth
	Engineering	Mathematics	Science	Breadth
Year 2	Engineering	Mathematics	Science	Breadth
	Engineering	Engineering	Science	Breadth
Year 3	Engineering	Engineering	Science	Breadth
	Engineering	Engineering	Science	Breadth
Year 4	Engineering	Engineering	Engineering	Elective
	Engineering	Engineering	Engineering	Elective
Year 5	Engineering	Engineering	Engineering	Engineering
	Engineering	Engineering	Engineering	Engineering

Figure 2 - Program structure for the Bachelor of Science

The Bachelor of Environments degree has a slightly different structure (Figure 3). It is a pathway for studies in civil engineering, environmental engineering and Geomatics. Students complete six foundational first year subjects in Environments, together with two mathematics subjects. Years 2 and 3 include the engineering subjects for their intended major, some additional Environments subjects and four more breadth subjects. The Bachelor of Biomedicine provides a pathway with a major in bioengineering leading to biomedical engineering.

Year 1	Environments	Environments	Environments	Mathematics
	Environments	Environments	Environments	Mathematics
Year 2	Engineering	Engineering	Environments	Breadth
	Engineering	Engineering	Environments	Breadth
Year 3	Engineering	Engineering	Environments	Breadth
	Engineering	Engineering	Engineering	Breadth
Year 4	Engineering	Engineering	Engineering	Elective
	Engineering	Engineering	Engineering	Elective
Year 5	Engineering	Engineering	Engineering	Engineering
	Engineering	Engineering	Engineering	Engineering

Figure 3 - Program Structure for Bachelor of Environments

Another major pathway for students will be through the Bachelor of Commerce. For this degree, students use their Breadth sequence as well as two elective opportunities during the Bachelor's degree to study engineering. Students must complete two additional (overload) subjects to prepare them for entry to the required Master of Engineering.

Conclusions

In 2008, the University of Melbourne will introduce six new undergraduate degrees as the first stage of the Melbourne Model. For engineering, this means students will have a broader first three years of education. This allows them to delay their final major choice as long as possible. However, students will still have to make some choices about possible majors on their enrolment day.

Contrary to popular belief, however, students will complete a substantial number of engineering subjects in their first three years. In fact, half of the degree is study in their intended major, with a further quarter of studies directly relevant. The structure is also sufficiently flexible that students can backtrack where required should they change their major along the way.

The combination of a broad three year education followed by a two year specialization will provide graduates with the type of education required for the resolution of the increasingly complex problems we are seeing in the 21st century.

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