An evaluation of Australian undergraduate engineering management education for flexible delivery

by

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submitted in fulfilment of the requirements for the degree of

Doctor of Technology

Deakin University
August, 2001
I certify that the thesis entitled: **An evaluation of Australian undergraduate engineering management education for flexible delivery**

submitted for the degree of: **Doctor of Technology**

is the result of my own research, except where otherwise acknowledged, and that this thesis in whole or in part has not be submitted for an award, including a higher degree, to any other university or institution.

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Abstract

This thesis examines issues in Australian undergraduate engineering management studies in the context of flexible learning delivery. It is proposed that, within an Australian context:

a) the management skills and competencies required by graduate engineers can be determined and classified on a rational basis, permitting an educational focus on those elements most appropriate for graduates; and

b) on-line and other computer-based technologies are a practical and effective method for the support of undergraduate engineering management studies.

The doctoral project incorporates:

- an examination of the nature of engineering management;
- a review of the relevant literature establishing the importance of management studies in undergraduate engineering courses;
- a review of historical and recent developments in Australian undergraduate engineering management studies;
- an investigation of the management skills and competencies required by graduate engineers - based on original research;
- an examination of flexible delivery of engineering education - based on professional practice experience; and
- an evaluation of case studies of flexible delivery of engineering management education - based on original research and professional practice experience.

A framework of ranked classified management skills is developed. Broadly, the ranking framework is generic professional skills, followed by general management skills and technical discipline specific management skills, followed by other professional discipline skills and theoretical skills. This framework provides a rational basis for design of undergraduate engineering management studies. This is supplemented by consideration of the management skills required for the future of engineering practice.
It is concluded that undergraduate engineering management education is well suited to delivery and support by on-line and computer-based technology. Recent developments in improved access to the Internet, software systems for on-line collaboration and changes in copyright legislation to create a broad-based right to communication via on-line media have contributed to the facilitation of on-line delivery of teaching and learning. It is noted that though many on-line infrastructure issues have been satisfactorily resolved, higher level issues will emerge as being crucial, including the academic staff development and reward for operating in an on-line teaching environment and the financial sustainability of on-line development and delivery of courses.
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Finally, I would like to thank the large number of respondents who participated in the survey exercises that formed part of the research activities of this project.
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<th>Description</th>
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<tbody>
<tr>
<td>AAEE</td>
<td>Australasian Association for Engineering Education</td>
</tr>
<tr>
<td>ABET</td>
<td>Accreditation Board for Engineering and Technology, Inc. (USA)</td>
</tr>
<tr>
<td>ACEA</td>
<td>Association of Consulting Engineers Australia</td>
</tr>
<tr>
<td>ACED</td>
<td>Australian Council of Engineering Deans</td>
</tr>
<tr>
<td>ACEME</td>
<td>Australasian Conference of Engineering Management Educators</td>
</tr>
<tr>
<td>ALN</td>
<td>Asynchronous Learning Networks</td>
</tr>
<tr>
<td>APEA</td>
<td>Association of Professional Engineers Australia</td>
</tr>
<tr>
<td>APESA</td>
<td>Association of Professional Engineers and Scientists Australia</td>
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<tr>
<td>ASP</td>
<td>Active Server Page</td>
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<tr>
<td>ASTEC</td>
<td>Australian Science, Technology and Engineering Council</td>
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<tr>
<td>ATSE</td>
<td>Academy of Technological Sciences and Engineering</td>
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<tr>
<td>BE</td>
<td>Bachelor of Engineering</td>
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<tr>
<td>BTech</td>
<td>Bachelor of Technology</td>
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<tr>
<td>CAD</td>
<td>Computer Aided Design</td>
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<tr>
<td>CAL</td>
<td>Computer Aided Learning</td>
</tr>
<tr>
<td>CAM</td>
<td>Computer Aided Manufacture</td>
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<tr>
<td>CD-ROM</td>
<td>Compact Disc - Read Only Memory</td>
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<tr>
<td>CMC</td>
<td>Computer Mediated Communication</td>
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<tr>
<td>CML</td>
<td>Computer Managed Learning</td>
</tr>
<tr>
<td>CPD</td>
<td>Continuing Professional Development</td>
</tr>
<tr>
<td>DEET</td>
<td>Department of Education Employment and Training</td>
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<tr>
<td>DEETYA</td>
<td>Department of Education Employment Training and Youth Affairs</td>
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<tr>
<td>HSC</td>
<td>Higher School Certificate</td>
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<tr>
<td>HTML</td>
<td>Hypertext Markup Language</td>
</tr>
<tr>
<td>ICT</td>
<td>Information and Communication Technology</td>
</tr>
<tr>
<td>IEAust</td>
<td>Institution of Engineers Australia</td>
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<tr>
<td>ISP</td>
<td>Internet Service Provider</td>
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<tr>
<td>IT</td>
<td>Information Technology</td>
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<tr>
<td>MBA</td>
<td>Master of Business Administration</td>
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<tr>
<td>OHS</td>
<td>Occupational Health and Safety</td>
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<tr>
<td>Abbreviation</td>
<td>Full Form</td>
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<tr>
<td>PDF</td>
<td>Portable Document Format</td>
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<tr>
<td>RPL</td>
<td>Recognition of Prior Learning</td>
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<tr>
<td>SME</td>
<td>Small to Medium Enterprise</td>
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<tr>
<td>TAFE</td>
<td>Technical and Further Education</td>
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<tr>
<td>TFME</td>
<td>Task Force on Management Engineering</td>
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<tr>
<td>UICEE</td>
<td>UNESCO International Centre for Engineering Education</td>
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<tr>
<td>VCE</td>
<td>Victorian Certificate of Education</td>
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<td>WWW</td>
<td>World Wide Web (the ‘Web’)</td>
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1 - Introduction

1.1 Change and engineering

It is true to say that the only remaining constant in life is the inevitability of change. This, in fact, was known in the fifth century BC by the Ionian philosopher Heraclitus who said, “Nothing endures but change”. What has changed since that time is that the rate of change is accelerating. This change applies generally to the higher education sector, as well as to engineering education. The engineering education process is fundamentally and systematically linked to the profession of engineering, and the changes in the nature of professional engineering practice are naturally reflected in changes in engineering education. In a recently published book Lloyd, et al. (2001) chart the history of engineering (and engineering education) in Australia from 1919, and identify three principal phases of development:

1919 - 1980
A long period of slow development, that none-the-less included a number of significant milestones, including:

- 1919 - formation of the Institution of Engineers, Australia (IEAust);
- 1946 - formation of the Association of Professional Engineers Australia (APEA);
- 1961 - the creation of the Professional Engineers Awards that established professional salary levels for degree and diploma qualified engineers; and
- 1980 - IEAust requirement for degree level qualification for recognition as a professional engineer.

1980 - 2000
A period of accelerating change for both engineering education and practice, culminating in developments that challenge the nature of professional engineering practice. In the late 1980s labour market ideologies produced a drive for competency-based recognition in professional occupations - the IEAust response was to develop a new structure for the engineering workforce that encompassed professional engineers (four-year qualified), engineering technologists (a new three-
year professional qualification) and engineering associates (two-year qualified). Other factors challenging the profession in Australia during this period included:

- globalisation;
- rapid technological advance;
- increasing environmental awareness;
- increasing social activism;
- low status for professional engineers and the ‘de-engineering’ of many senior positions in industry;
- a reduction in the size of the public sector - traditionally a significant employer of engineers;
- rising contract and itinerate employment of professional engineers; and
- a decline in membership of the IEAust to approximately 30% of Australian engineers of working age.

The future
It is expected that there will be continuing (r-)evolution and ever-present change for the profession that will challenge its very existence.

These developments correspond with the exponential growth in technology, and mirror other general changes in society. It is against this backdrop of change that the program of doctoral studies documented in this thesis is set. Engineering education is also set in, and influenced by, developments in the higher education sector generally.

1.2 Change in higher education
The changes in higher education in Australia reflect international developments. These changes include (Australian Vice Chancellors Committee, 1997):

- increasing globalisation of technology, communications and commerce;
- increasing numbers of students (through population growth and increased participation rates);
- increasing diversity of students (including school-leavers, postgraduates, mature-aged students and industry-based students);
- diversity of study modes (including on-campus, off-campus and just-in-time);
- the increasing use of on-line delivery and other new information technology;
- real reductions in the public funding of higher education, and the need to seek funding/income/earnings from external sources;
- increasing productivity and the requirement to do more with less;
- increased reporting requirements and bureaucracy;
- increasing competition between and within institutions; and
- ageing research infrastructure.

Additional recent changes in Australian higher education include:
- recognition of the need to enhance management and leadership skills in Australian business and industry;
- formalisation of articulated educational pathways to assist students to (re-)enter studies to upgrade their academic qualifications - in the engineering discipline this process includes integrated educational paths from the trade level through to doctoral level, for school-leavers, mature-aged entrants and those with varying prior qualifications (Lloyd et al., 1989);
- the Dawkins-era (mid to late 1980s, under the then Federal Education Minister John Dawkins) phase of rationalisation that led to the amalgamation of many higher education institutions and the creation of new multi-campus universities; and
- the increasing importance of the overseas education market - both in attracting international students to study in Australia, and in offering the education programs of Australian universities in other countries.

Accelerating technological change impacts on education in two principal ways. Firstly, advances in technology require people to learn new skills to understand and effectively operate new technology. Secondly, advances in technology offer new methods for teaching and learning. The former impact has created a new and growing education market segment of ‘lifelong learners’, who are likely to prefer to study away from the confines of a university campus; the latter impact has provided many new tools for the educator.
In particular, information and communication technology (ICT) has created new opportunities and avenues for bridging the gap between the classroom and distance education students, as well as providing entirely new educational experiences for traditional, on-campus students. Taylor (1996) charts the historical progression of distance education models (and their appropriation of emerging ICTs) thus:

1. the correspondence model (print based);
2. the multi-modal model (highly developed structured resources, including videotapes, audiotapes and computer assisted learning);
3. the tele-learning model (interactive telecommunications, instructional use of audiographics, and two-way tele- and video-conferencing);
4. the flexible learning model (CD-ROM, Internet).

Global communications networks will provide an opportunity for increased access to education, and the market potential of this growing audience of students has not been lost on the private sector. Cunningham et al. (1998) in a report on the involvement of global media and communication networks in higher education provision across borders note that, while there is much hype regarding the involvement of global media networks in higher education, the reality appears to have a slightly different focus. Currently, commercial interests in higher education are focussed on the carriage of educational content produced by others. The largest corporate involvement in education is via the ‘corporate university’ model, which is based on the provision of training (as distinguished from education) to large corporations. Cunningham et al. (1998) see that growth in this area increasingly competing with higher education for corporate funding, and, that, “Australia’s higher education sector [must] recognise the segmentation of the market globally and develop strategies to compete successfully in the profitable lifelong learning market.” (Cunningham et al., 1998, xvii).

Gardner (2000) suggests that schools of all types have been remarkably resistant to change (perhaps surpassed only by the church), but that changes in technology will revolutionise education, with the computer becoming the central focus as the source of information, and learning becoming more individualised to suit the needs, pace and place of the learner. With these changes will come changes for the institutions
and staff involved in the development and delivery of education. Infrastructure and staff skills will require on-going enhancement as the pace of technological and social change accelerates. Staff development will be a key factor in sustaining the competence, relevance and competitiveness of higher education institutions.

1.3 Change in engineering education

The changing landscape of higher education in Australia and the changes being experienced by the engineering profession, as well as broader societal change, have, in turn, brought about change in engineering education in Australia. A measure of the long-term change in engineering education can be found in the expansion of the discipline specialisms over time. In 1920, six engineering specialisms were offered in Australian universities. By 1979 this number had risen to 17, and in 2000, 54 specialisms could be found (Lloyd et al., 2001).

Perhaps the most immediately obvious change in engineering education in Australia is the revision of the undergraduate course accreditation process initiated in 1997 by the IEAust. This was in direct response to the recommendations of a major review of engineering education in Australia (Johnson, 1996a) sponsored by the IEAust, the Academy of Technological Sciences and Engineering (ATSE), the Australian Council of Engineering Deans (ACED) and the Commonwealth Department of Employment, Education, Training and Youth Affairs (DEETYA).

This review identified and addressed many issues, some of which would be familiar to readers of the Williams review of engineering education (Williams, 1988) from nearly a decade before (such as the low participation rate of female students and the generally poor preparation of engineering graduates for the broader business and societal context of engineering practice), as well as some more contemporary issues (such as sustainability, globalisation, diversification of the engineering student population, changes in educational thought and new developments in educational technology). The review involved wide-ranging national consultation via six task force groups, these being:

1. interface with students;
2. interface with industry;
3. interface with the profession;
4. educational programs;
5. institutional policies and systems; and
6. interface with the community.

When the report of the Review of Engineering Education was released in December 1996, it was prefaced by the review chair, Professor Peter Johnson, with the following words:

“[The report] is recommending no less than a culture change in engineering education which must be more outward looking with the capability to produce graduates to lead the engineering profession in its involvement with the great social, economic, environmental and cultural challenges of our time.” (Johnson, 1996a, 6).

The report includes 14 recommendations that cover the range of issues addressed by the six task forces. Changes to the profession including globalisation and information technology are identified. The requirement for a balance between basic science, engineering fundamentals, management and business, and ethics is reaffirmed. The need for attention to social, environmental, political and economic context is also reiterated. The need to reduce overloading of curricula, accommodate alternative modes of learning, facilitate entry from non-traditional backgrounds, and recognise skills and prior learning is identified. Among many other issues critical to the future of engineering education, the report also recognises that information technology and on-line delivery will revolutionise all forms of education in the near future. “Why should any lecturer continue to perform in traditional mode year after year when world-best courseware will be available on the Internet?” (Johnson, 1996b, 111).

At various points the report identifies the following closely related issues:
• the development of generic professional skills - including communications skills and the capacity for life-long learning;
• continuing education (in various forms) should be seen as an important part of an engineering career; and

• ‘flexibility’ in basic and continuing engineering education - encompassing opportunities to articulate/upgrade academic qualifications, recognition for prior learning and course delivery modes.

These recommendations reflect the reality of technological and organisational change in the real world. Technology professionals and para-professionals need to be adaptable and undertake continuous professional development - educational providers must offer learning opportunities for these people that go beyond a four-year, full-time, on-campus undergraduate degree open only to highschool leavers.

As previously noted, the first clear, tangible result of the review of engineering education was a new course accreditation process for Australian undergraduate engineering programs. Prior to 1997 the course accreditation process was highly prescriptive, focussing on course content and other inputs in a principally open-loop fashion. The review proposed more freedom for, and scope for innovation by, individual engineering schools in determining their course content and modes of delivery, moving from a prescriptive system of accreditation to one focusing more on demonstrated outcomes and graduate attributes.

The focus in this section has been on changes in engineering education in Australia. However, the issues presented broadly reflect the findings and recommendations of similar reviews of engineering education in North America (American Society for Engineering Education, 1994) (The Canadian Academy of Engineering, 1993) and Europe (Working group on lifelong learning and continuing education in engineering, 1998). Engineering education around the world is moving from a narrow focus on technology to a more holistic view of the interaction between society and the engineering process, and engineering education design and delivery mechanisms are evolving to cater for this. Not surprisingly, the developments in engineering education in Australia are not unique. The impacts of international trends, such as globalisation, reduction of the public sector and the advance of information technology are evident on engineering education systems around the world.
1.4 Change in engineering management education

Over more than three decades the importance of management skills for engineers in Australia, and hence undergraduate engineering management education, has been established, reaching zenith in 1990 with a requirement by the IEAust that within undergraduate courses “the total of all management related components rises to the vicinity of 10% by 1995.” (Institution of Engineers Australia, 1991a, 11). Figure 1 documents this history, which will be presented in detail in Chapter 2. From 1990 to 1997 the requirement for significant management-related undergraduate studies was enshrined in the course accreditation requirements of the IEAust. It is now widely agreed that studies in engineering management form an important and integral component of engineering undergraduate education.

With the release of the post-engineering education review accreditation guidelines, and subsequently a revision of the IEAust’s competency standards for professional engineers (Institution of Engineers Australia, 1999b), the status of engineering management studies in undergraduate programs has come into question. The requirement for management studies in the accreditation guidelines has been significantly downgraded, and management-related elements in the new competency standards (along with some other elements) have had their status changes from ‘core’ to ‘optional’ requirements. These developments, while flowing from the Australian review of engineering education, seem at odds with the intent of the review, as well as standing in contrast to the findings of recent international reviews of engineering education. The background to, and ramifications of, these recent changes will be discussed in detail in Chapter 2.

1.5 Scope of investigations

1.5.1 Project rationale and significance
The above has briefly shown how changes in the nature of Australian engineering practice (including a massive reduction of the traditional employment and career opportunities in the public sector and a decline in professional and social status for engineers), combined with changes in Australian higher education (including
<table>
<thead>
<tr>
<th>Year</th>
<th>Source/Report</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1968</td>
<td>Lloyd - <em>The education of professional engineers in Australia</em></td>
<td>Engineering management is intimately coupled to technical work</td>
</tr>
<tr>
<td>1972</td>
<td>PE Consulting - <em>The role of the professional engineer</em></td>
<td>92% of practicing engineers support management studies for undergraduates</td>
</tr>
<tr>
<td>1979</td>
<td>Lloyd et al. - <em>Engineering manpower in Australia</em></td>
<td>Importance of management for engineers Low levels in undergraduate courses</td>
</tr>
<tr>
<td>1987</td>
<td>IEAust - <em>Task force on management education</em></td>
<td>Not enough emphasis given to ‘management’ skills in studies</td>
</tr>
<tr>
<td>1988</td>
<td>Williams - <em>Review of the discipline of engineering</em></td>
<td>Coverage of sciences and skills was satisfactory, but ‘management’ was not</td>
</tr>
<tr>
<td>1989</td>
<td>IEAust - <em>Task force on management education</em></td>
<td>Policy on management studies in engineering undergraduate courses - the ‘10% rule’</td>
</tr>
<tr>
<td>1992</td>
<td>APESA - <em>Skills for the future report</em></td>
<td>Confirmed deficiencies reported by Williams and reiterated prior calls for improvement</td>
</tr>
<tr>
<td>1993</td>
<td>IEAust - <em>National competency standards for professional engineers</em></td>
<td>Identified competencies required by engineers, including management skills</td>
</tr>
<tr>
<td>1994</td>
<td>DEET - <em>Report on the impact of Discipline review of engineering</em></td>
<td>Concluded that some progress has been made in management studies</td>
</tr>
<tr>
<td>1995</td>
<td>Karpin - <em>Enterprising Nation ‘The Karpin report’</em></td>
<td>Recommendations for undergrad courses to enhance management &amp; leadership skills</td>
</tr>
<tr>
<td>1996</td>
<td>IEAust, et al. - <em>Changing the culture</em></td>
<td>Recommendations for the future of engineering education in Australia</td>
</tr>
<tr>
<td>1999</td>
<td>IEAust - <em>National generic competency standards for stage 2</em></td>
<td>Management competencies now reduced to ‘elective’ status</td>
</tr>
<tr>
<td>1999</td>
<td>IEAust - <em>Manual for accreditation of professional engineering courses</em></td>
<td>‘10%’ rule replaced with more general requirement for management studies</td>
</tr>
</tbody>
</table>

Diagram: International reports confirm the importance of undergraduate management studies → **NOW** Undergraduate management education recognised as important... → Demand from engineers for postgraduate studies in management → *...where to for engineering management studies in Australia?*

Figure 1 - Overview of the development of undergraduate engineering management education in Australia
increased numbers and diversity of students, reduced public funding, new modes of study and the IT revolution) have combined with existing historical issues to bring about change in Australian engineering education. Engineers, their institutions and their education were criticised for being too narrowly focussed on technology and disregarding the social impacts of that technology. This made study and a career in engineering unattractive to many sections of society, diminished the standing of the profession in the eyes of the wider public and decreased the efficiency of the profession in the delivery of social benefits to society.

The Australian review of engineering education sought to address these issues by transforming engineering education so that it is:

- opened up - in terms of entry points and modes of delivery;
- made relevant by modernising and broadening the curriculum; and
- outcomes focussed, rather than relying on prescriptive input specifications.

In the process of this change, engineering management studies, formerly enjoying a prominent status in the accreditation requirements for engineering courses, appear to have been an unintended casualty of change.

The recent recommendations for undergraduate engineering courses, the changing perceptions of management in general, the recent broadening of undergraduate student backgrounds and study modes and the current and likely future impacts of information technology on teaching and learning make the time highly appropriate for a review of the design, delivery and effectiveness of undergraduate engineering management courses, particularly in the context of flexible delivery. This is the fundamental rationale for, and significance of, the project documented in this thesis.

1.5.2 The hypotheses
This thesis documents a doctoral project that examines issues in Australian undergraduate engineering management studies in the context of flexible learning delivery. It is proposed that, within an Australian context:
a) the management skills and competencies required by graduate engineers can be
determined and classified on a rational basis, permitting an educational focus on
those elements most appropriate for graduates; and
b) on-line and other computer-based technologies are a practical and effective
method for the support of undergraduate engineering management studies.

1.5.3 Project framework
The doctoral project incorporates the following sequence of work.

A literature-based investigation that sets the context for the project by examining:
- the nature of engineering management;
- the history of undergraduate engineering management studies in Australia that
  establishes their recognised importance in the curriculum; and
- the recent developments in undergraduate engineering management studies in
  Australia that signpost fundamental changes in this area.

As noted previously, historical developments in Australia lead to a policy of
mandatory engineering management studies in undergraduate courses. However,
policy is one thing, and implementation is another. Based on original research, a
survey-based investigation of the implementation of the undergraduate engineering
management studies policy in Australia from the perspectives of some of the
stakeholders in undergraduate engineering management programs is presented. This
section explores the management skills/competencies that should be imparted by an
engineering undergraduate course by identifying the management skills/
competencies viewed as important by three stakeholder groups relevant to the
project; these groups being Australian academics involved in the design and delivery
of engineering management studies, current undergraduate students studying in
flexible mode and recently graduated engineering students. The findings from the
three surveys are compared with each other, and then with similar surveys presented
in the international literature to identify a framework in which to categorise
engineering management skills, and rank the relative importance of these categories.
An outcome from the project work to this point is that generic professional practice skills are identified as the most important elements of management studies. This leads to a need to understand the nature of these skills and effective methods for their delivery and assessment. A case study from the professional practice of the author is presented where an existing study unit was adapted to incorporate a number of new assessment tasks aimed at the development of students’ generic professional practice skills. A pre-test/post-test survey activity is presented to evaluate the perceived effectiveness of these assessment tasks from the perspective of the student.

The second principal project element is flexible delivery, specifically, flexible delivery of engineering management studies. The first component presented is based on the research and practice of the author and presents the experiences and personal reflections of the author as an academic operating in an environment of flexible delivery of engineering and technology education. Here, the key challenges for ‘flexibility’ in flexible mode engineering programs are identified, as is the key emerging issue of on-line course delivery.

Secondly, once it has been shown that on-line educational technology can be managed effectively from an institutional perspective, it is important to establish if this technology is effective/attractive/accessible from a student’s perspective. This is achieved using two case study evaluations from the professional practice of the author in the form of surveys of student cohorts to evaluate the application of on-line technology in the context of an engineering management unit. The surveys seek to:

- identifying student readiness to adopt on-line technologies in their education; and
- evaluating the effectiveness of on-line technologies in management studies.

A discussion of the project work is presented to draw out the critical issues and examine their implications. The related literature is used to highlight the value as well as the limitations of the proposed framework of management skills, as well as to look forward to identify skills that may be important in the future. The implications of on-line delivery in engineering education and, in particular, the flexible delivery of management education are discussed. Finally, the findings of the project are related
to the professional practice context of the author as a catalyst for improving professional practice.

The research methodologies employed include:

- historical study – “…appropriate for those data that are primarily documentary in nature or literary in form.” (Leedy, 1989, 123). An investigation of the development of engineering management studies in Australia over a period of three decades as documented in the literature so as to establish the historical driving forces in engineering management education and the context in which current developments have arisen;

- surveys - including both descriptive (“…appropriate for data derived from simple observational situations…through benefit of questionnaire or poll techniques.” (Leedy, 1989, 122)) and analytical (“…appropriate for data that are quantitative in nature and that need statistical assistance to extract their meaning.” (Leedy, 1989, 123)) elements to characterise and evaluate a number of sample populations and their views on engineering management education or computer applications in engineering management education; and

- ‘one group pretest-posttest’ pre-experimental design – “…where a single group (1) has a pre-experimental evaluation, then (2) is influenced by a variable, and, finally, (3) is evaluated after the experiment.” (Leedy, 1989, 300). An investigation to characterise changes in students’ attitude to computer conferencing following exposure to a computer conferencing environment in the context of engineering management studies.

Table 1 provides a framework/overview of the structure of both the sequence of project work and the presentation of the work in this thesis, identifying the key project components, the research methodologies employed and the project outcomes.

The area of investigation - engineering management education - necessarily includes all three of its component foundation disciplines, the combinations of these disciplines (engineering management, management education and engineering education), as well as the intersection of all three. The unique intersection space of
### Table 1 - Overview of project framework and thesis outline

<table>
<thead>
<tr>
<th>Chapter</th>
<th>Process</th>
<th>Method</th>
<th>Outcome(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>-</td>
<td>Rationale and objectives for the doctoral project</td>
</tr>
<tr>
<td>2</td>
<td>Investigate the theme of engineering management;</td>
<td>Literature review; Historical study</td>
<td>Definition(s) of what constitutes 'engineering management'; Historical and regional context for the doctoral project</td>
</tr>
<tr>
<td></td>
<td>Review the history of, and recent developments in engineering</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>management education in Australia</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Consult particular engineering management stakeholder groups;</td>
<td>Survey; Statistical analysis;</td>
<td>Classification of engineering management competencies and skills required by graduates;</td>
</tr>
<tr>
<td></td>
<td>Compare their requirements for engineering management with those</td>
<td>Literature review</td>
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<tr>
<td></td>
<td>previously published</td>
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<tr>
<td>4</td>
<td>Investigate student responses to learning activities traditionally</td>
<td>Pre-test/ post-test survey;</td>
<td>Approaches to improve the development of generic professional practice skills in engineering management studies</td>
</tr>
<tr>
<td></td>
<td>‘consigned’ to the engineering management stream</td>
<td>Practice case study</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Critically investigate the application of ‘flexible delivery’ to</td>
<td>Practice case study</td>
<td>Benefits and limitations of flexible and on-line delivery in the context of engineering studies</td>
</tr>
<tr>
<td></td>
<td>engineering education</td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Investigate the application of on-line educational technologies in the</td>
<td>Survey; Pre-test/ post-test</td>
<td>Identification of student readiness to adopt on-line technologies; Evaluation of effectiveness of on-line technologies in management studies; Assessment of student attitudes to on line technologies in education</td>
</tr>
<tr>
<td></td>
<td>delivery of engineering management education</td>
<td>survey</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Synthesise, review and evaluate project work and findings</td>
<td>-</td>
<td>Critical issues and findings arising from the project work</td>
</tr>
<tr>
<td>8</td>
<td>Summarise project outcomes</td>
<td>-</td>
<td>Conclusions from the project work</td>
</tr>
</tbody>
</table>

Engineering management education is relatively small, and this is reflected in the relative dearth of existing literature in this area. The project will draw upon the general literature of the foundation disciplines, their more specialised combinations and their intersection (such that exists), to add to the body of knowledge in the area of investigation through professional practice experience and original research.

Engineering can be superficially considered as a ‘hard’ discipline dealing with the application of scientific principles and well understood technologies to produce
repeatable outputs. However, an examination of the engineering process reveals that it is composed on many elements, most of which are not deterministic (Wenk, 1996). Brier (2000) demonstrates how engineering differs only in shade, not nature, from other creative arts:

“Techne, which is often translated as ‘art’, is the productive craftsmanship of constructing something. It relies on a blend of reasoned knowledge; know-how, tacit knowledge and aesthetical knowledge...You can imagine a spectrum with engineering at one pole and theatre at the other. These are concrete, variable and context-dependent activities using practical rationality governed by a conscious goal of producing something artificial, useful and often aesthetically pleasing.” (Brier, 2000, 447).

Management and education have even more non-deterministic elements than engineering, both having a common ground in the organisation, interpretation and transformation of individuals, groups and knowledge. This project will necessarily deal with ‘soft’ issues and the interpretation of evidence, although, this will be conducted in a framework of comparison to existing bodies of knowledge and rational research methodologies. The thesis propositions will provide an overarching structure to the work undertaken.

The engineering workforce is composed of a systematically related team of occupations (Lloyd and Palmer, 2000). The IEAust’s National Generic Competency Standards (Institution of Engineers Australia, 1999b) identify the following occupational categories that make up the engineering workforce in Australia:

- professional engineer;
- engineering technologist;
- engineering associate;
- engineering technician; and
- engineering tradesperson.

Professional engineer and engineering technologist occupying the ‘professional’ occupational classifications of the engineering team. This project primarily addresses the initial preparation of professional engineers, specifically regarding undergraduate
engineering management education. This project does not directly address issues related to the preparation of engineering technologists or postgraduate engineering studies (that might be undertaken by both professional engineers and engineering technologists). It does, however, acknowledge the intimate relationship between the members of the professional categories of the engineering workforce, their undergraduate studies and engineering postgraduate study programs.

1.6 Other matters

While this thesis and the project work it documents seek to test the veracity of particular propositions, for the author, the work completed has been a process of professional development as well as seeking particular outcomes. During the course of the project the author has:

- developed an holistic conception of scholarship, encompassing discovery, integration, application and teaching, that has advanced his own professional practice significantly;
- investigated, planned and applied research methodologies; and
- exercised and developed technical and scholarly writing skills for publication.

The majority of the work documented in this thesis has been previously presented at conferences and published in refereed journals. These publications are noted in the List of References or Bibliography as appropriate, and included as-published in Adobe Acrobat Portable Document Format (.PDF) files on the CD-ROM inserted at the rear of this thesis. These publications are included for academic purposes only, and remain the copyright of the respective copyright holders. These publications may be viewed on any computer that has an Internet browser and the Adobe Acrobat viewer program installed. The following steps are required to view the publications:

- insert the CD-ROM into the CD-ROM drive;
- open the CD-ROM drive using the computer file manager;
- locate the file INDEX.HTM;
- launch this file to open it - this will cause the Internet browser to load with the publication index Web page displayed;
- select the publication(s) to view from the index Web page as required.
Statistical comparisons have been used at various points in this project to test the significance of observed values and distributions of values. These are explained in Appendix I - Explanation of statistical inferences.
2 - Undergraduate engineering management studies in Australia

2.1 Introduction

One of the central themes of this project is undergraduate engineering management studies in Australia. This chapter establishes the context for the project. This will be done by:

- investigating what constitutes ‘engineering management’; and
- investigating the history and more recent developments in undergraduate engineering management studies in Australia.

2.2 What is engineering management?

The modern disciplines of engineering and management are inextricably linked. Frederick Winslow Taylor (1856-1915), an American mechanical engineer, known as the ‘father of scientific management’, first developed methods of work study and attaching financial reward to performance. In 1911 he published the book Principles of Scientific Management, though these days he is more commonly remembered in the term ‘Taylorian’, used in a derogatory sense to describe work methods that are repetitive and dull. Henry Laurence Gantt (1861-1919), another American mechanical engineer, adapted Taylor’s methods and is known today for developing charts that graphed project performance versus elapsed time. The French mining engineer Henri Fayol (1841-1925) believed that management was the most important function in industrial organisations. His division of management into ‘planning, organising, leading, coordinating and controlling’ is still widely held today. Fayol was perhaps the first to note in print the incomplete preparation of engineering graduates:

“Our young engineers are, for the most part, incapable of turning technical knowledge received to good account because of their inability to set forth their ideas in clear, well-written reports, so compiled as to permit a clear grasp of the results of their research or the conclusions to which their observations have led them.” (Fayol, 1949, 79).
Engineering continues to be linked to management and business. Of the top 1000 publicly listed American companies in 1998, the most widely held qualification of the chief executive officer was engineering (Anonymous, 1998). Engineers were prominent as leaders of organisations during the first industrial revolution, and are again commonly the founders/leaders of new organisations arising from the second industrial revolution based on communications (Anonymous, 1998).

To be able to investigate management studies in engineering courses it is essential to define what the term ‘engineering management’ means. The following are some examples.

“Few people would dispute the proposition that shortly after beginning their careers, many professional engineers move from spending the bulk of their time solving technical problems to doing other things,...They are managerial activities. Management can be defined in many different ways, most of which include reference to planning, organising, controlling, leading, directing, allocating resources, communicating and co-ordinating.” (Samson, 2001, xvi).

“Most graduate engineers in business in Australia will devote only a small part of their working lives to traditional engineering activities...Instead, they will spend most of their working lives in activities which might be termed management activities, that is activities related to planning, organising, controlling, communicating, decision-making and so on.” (Kinsky, 1994, xiii).

“...engineering managers are under pressure to achieve marketable results focusing on quality, cost, and speed. This requires effective planning, organization, and integration of complicated multidisciplinary activities across functional lines and a great deal of people skills.” (Thamhain, 1992, v).

“Between the inception and completion of any engineering project there is a vast expanse of management and administrative tasks. Each of these, however, will be seen as connected with one of the six basic management functions:
• planning
• organising
• staffing
• directing
• controlling
• co-ordinating” (Antill and Farmer, 1991, 3).

All of these definitions incorporate some form of the commonly accepted functions of general management, that is ‘planning, organising, leading and controlling’. So, obviously, an engineering manager is not too far removed from any other kind of manager, but not quite the same either. Perhaps this essential difference is best described by Babcock (1996):

“The engineering manager is distinguished from other managers because he [or she] possesses both the ability to apply engineering principles and a skill in organizing and directing people and projects. He is uniquely qualified for two types of jobs: the management of technical functions (such as design or production) in almost any enterprise, or the management of broader functions (such as marketing or top management) in a high-technology enterprise.” (Babcock, 1996, 14).

Engineering management is the application of general management skills to the task of managing engineering activities. This definition also highlights the general nature of the management task - it is quite possible for an engineering manager to focus on the management of technological activities, or to become involved in the management of other activities that support the engineering function, or even to move completely into general management. From a systems perspective, engineering management is the factor that integrates all the elements of the engineering process.

It is important to understand the functions of management (planning, organising, leading, controlling, etc), but they do not tell us what areas of knowledge an engineering manager requires to be able to apply these functions to the management of technology. Obviously, it is impossible to be prescriptive here, as every manager
(be they a manager of engineering or any other business function) faces a unique set of circumstances. For the practising professional engineer, their experience of management is likely to change as their career develops. A typical progression might include several of the following phases:

- as a graduate: focus of self-management in the efficient completion of tasks;
- as an experienced engineer: responsibility for an engineering team;
- as a senior engineer: responsibility for an engineering project;
- as a functional manager: responsibility for departmental operations, budget and coordination;
- as a general manager: coordination and operation of all business functions;
- as a sole practitioner: total technical and business management responsibility; and
- as an entrepreneur: establishment of a new business enterprise.

Just as it is impossible for an undergraduate course to provide students with all of the technical knowledge they will ever need, it is also clearly impossible to equip an undergraduate with all of the management skills they will need during their career. However, there has, in the past, existed guidance for those developing and delivering undergraduate engineering courses as to what areas of knowledge and skill should be included in management studies. As will be noted again later, this guidance has recently been significantly altered and weakened.

The IEAust in its 1991 Accreditation Policies and Procedures relating to Professional Engineering Undergraduate Courses provides a ‘Model Study Structure’ for undergraduate management studies. It is important to note that the model offers a suggested course content, and is not intended to be prescriptive, but it does provide one view of the basic management knowledge required by engineering graduates. The actual model study structure is very detailed, but an appreciation of the content can be gained from the titles of the 17 suggested units of study (Institution of Engineers Australia, 1991b) given in Table 2.

The suggested model study structure, if fully implemented, would provide a good coverage of engineering management issues at the undergraduate level. It also provides an insight into the diverse range of skills needed by the engineering
Table 2 - IEAust model study structure for undergraduate management studies

| Introduction to engineering management | Marketing for engineers   |
| Communication for engineers            | Engineering finance       |
| Economics                               | Management science        |
| Accounting for engineers                | Human resource management |
| Law for engineers                       | Operations and quality management |
| The engineer and society                | Business strategies for engineers |
| Organisational behaviour                | Engineering and project management |
| Engineering economics                   | Engineering innovation    |
| Managing people                         |                           |

manager. It is self-apparent that if fully implemented, the suggested study structure would be a significant component of an undergraduate course. It would not fit into a one or two unit elective option, but requires a fully-fledged management sub-major stream across the course. Such a weighting appropriately reflects the importance of management to the long-term career of the practising professional engineer.

Another view of the attributes required by an engineering manager can be obtained from the IEAust’s 1993 National Competency Standards for Professional Engineers. The standard defines 11 ‘units of competency’, which are further divided into ‘elements of competency’, which are further divided into ‘performance criteria’. Amongst the 11 identified units of competency are (Institution of Engineers Australia, 1993):

- professional engineering ethics and principles;
- management; and
- communication.

Within these units of competency, the defined ‘elements of competency’ include:
- Follow an accepted code of ethics;
- Plan, organise, direct and control tasks, people or resources;
- Perform economic, financial, legal, marketing and business management;
- Manage human resources;
- Train and develop subordinates in the work-place;
• Apply project management principles;
• Apply self-management principles;
• Communicate effectively in the English language;
• Present, report on and advocate engineering ideas; and
• Prepare, comprehend and communicate engineering documents.

Aside from successfully managing their own time, the engineering team, engineering projects, the engineering function or the engineering enterprise, there is another management activity that the professional engineer appropriate educated in management is well qualified for - the management of technology. The link between technological advance and economic growth is outlined in the recent report of the Australian government’s chief scientist:

“Reviews of growth accounting models show that, in the US, 49 per cent of current economic growth came from technical progress and that 88 per cent of growth in the first half of the twentieth century came from technical change.” (Batterham, 2000, 20).

Khalil (1993) proposes that the successful management of technological development and change requires technically competent managers, but in 1993 he observed:

“We have seen the failure of most current engineering disciplines in developing engineers who can manage stable technological systems, let alone fast changing global dynamic systems of today and tomorrow. We have also witnessed the failure of business schools in developing the professional manager who has knowledge of the intricacies of technology and technological development” (Khalil, 1993, 65).

Khalil suggested that engineers with appropriate management skills could be the key to the effective management of technology and the advancement of growth.

The literature provides definitions of engineering management, describes the functions of engineering management and suggests skills/competencies required of
the engineering manager. This information will be supplemented in Chapter 3 with surveys of engineering management education stakeholders. The remainder of the current chapter places ‘engineering management’ in an Australian context by reviewing the historical development of undergraduate engineering management studies in Australia.

2.3 The need for management education

It is well known that most engineers make the transition from technical to management responsibilities some time in their careers (Babcock, 1996). The career advancement of engineers depends principally on their ability to become effective managers of the engineering function in particular, and of technology in general (Kinsky, 1994). Surveys of students, graduates, experienced engineers and employers of engineers all confirm the importance of management skills, and that these have not been delivered well in the past by engineering undergraduate courses. The American Society for Engineering Education (as far back as 1955) concluded:

“It is clearly recognized that many engineers progress into managerial and top executive positions in industry and government. For such individuals the foundation should be laid in college for an understanding of human relationships, the principles of economics and government, and other fields upon which the engineering manager can build.” (Grinter, 1955, 7).

The Higher Engineering Education for Europe (H3E) group report:

“The real world is not as precisely defined as technical courses at school and university would lead students to believe...The varied problems that arise in daily professional life are not so restricted. They demand varied responses, with an integration of insights brought to bear from many different perspectives (technical, manufacturing, psychological, marketing, historical, economic, etc.).” (Working group on lifelong learning and continuing education in engineering, 1998, Basic studies - technical competence, ¶ 3-4).
In an Australian context, the former Chief Executive of the IEAust reported in 1996 that:

“This technical virtuosity is often necessary, but never sufficient. A major survey conducted for the Institution earlier this year revealed that 30% of members work in non-engineering roles, and over 40% are primarily involved in management.” (Webster, 1996, ¶2).

In Australia, as far back as 1968 it was identified that:

“In all phases of practice in the profession the technical work is coupled, to a greater or lesser extent, with engineering management.” (Lloyd, 1968, 43).

A 1972 survey of 1426 practising Australian engineers found that 92% of respondents indicated management studies should be included at the undergraduate level (PE Consulting Group (Australia) Pty Ltd, 1972).

Lloyd et al. (1979) identified the increasing importance of management in the success of technological development, the desirability for managers of engineering activity to have an engineering background and that the formation of engineering management skills should begin in undergraduate courses. In the same document an analysis of the content of tertiary engineering courses revealed a wide variation and general lack of management studies in Australian undergraduate engineering courses:

“Most of the universities include a small amount of management studies, but some include none.” (Lloyd et al., 1979, 220).

The 1988 Review of the Discipline of Engineering, chaired by Williams, extensively investigated many aspects of engineering education, including surveying employers of graduates, recent graduates and students to determine their views on the content of undergraduate courses. From the employers’ perspective, the review found:
“The majority of employers judged as “satisfactory” the emphasis given to the basic sciences, the skills, knowledge and practice of the particular discipline of engineering studied, ... But they judged as unsatisfactory the emphasis given to oral and written communication skills, industrial relations and the management of people, the management of costs and resources, engineering as part of a broader business context, and the involvement with non-engineering disciplines in project work.” (Williams, 1988, 31).

From a national survey of students and graduates, the review identified those components of the course with the largest discrepancy in emphasis between “what should have been covered” and “what has been covered” as, “industrial relations, management of people, management of costs and resources, written and oral communication skills, social responsibility in engineering and engineering as part of the business context”. The recommendations of the review included references to the importance of the “human side” of technology and the need for a more emphasis on the deficiencies identified by employers, students and graduates.

A 1987 IEAust task force on management education reported similar concerns. A submission to the task force by the Association of Consulting Engineers, Australia (ACEA) observed that, “most engineers were not people orientated, and that many lack communication skills”. The ACEA submission proposed a need to moderate the emphasis given to purely technological subjects with an early grounding in management studies. In particular, the ACEA argued that minor increases in a small base of management course content would not be sufficient, and that,

“The need is for management to occupy a place in the syllabus that places it on a par with the major technological elements. We consider that 15 per cent of total course time would be appropriate.” (Institution of Engineers Australia, 1991b, 3).

For more than 20 years the call had been increasing for an improvement in the preparation of engineering graduates in the area of management skills. For this to be effective, it would have to be made a course content ‘requirement’ in the course accreditation process of the IEAust.
2.4 The requirement for management education

Lloyd (1994) describes how the IEAust created the task force on management engineering (TFME) in 1989. One of the goals of the TFME was to formulate a policy for management education in engineering undergraduate courses. A draft policy was quickly developed and circulated to relevant professional bodies, gaining wide support, many constructive comments and minimal negative criticism. Following a process of consultation and review with stakeholders, in 1990 the Council of the IEAust approved the Policy on Management Studies in Engineering Undergraduate Courses. The policy became known as the ‘10% rule’, its essence being:

“From January 1991 the Institution will require at least a 5% management content in all professional engineering undergraduate courses and that the total of all management related components rises to the vicinity of 10% by 1995.” (Institution of Engineers Australia, 1991c, 1).

The policy was incorporated in the IEAust’s Guidelines for Management Studies in Engineering Undergraduate Courses (Institution of Engineers Australia, 1991b), which provided a rationale for management studies in undergraduate engineering courses, suggested a model study structure comprising 17 units of management studies, as shown in Table 2, and suggested a syllabus for each of the units. Though quite detailed, the guidelines were clearly prefaced with the rider that they were not intended to be prescriptive, and that each school should devise their own approaches and subject arrangements. The history of the development of the ‘10% rule’ is also documented by Young (1991).

With the adoption of the policy on management studies in engineering undergraduate courses there existed a requirement for management content in engineering undergraduate courses, and until recently, the policy had been the reference point for undergraduate engineering management studies in engineering. In the context of undergraduate education, it should be noted that the term ‘engineering management’ actually covers a wide range of material that could be classified as non-technical
and/or generic professional skills - this can be readily appreciated by examining the topic areas presented in Table 2.

It should also be noted that this policy was not greeted with unanimous support by engineering schools around Australia. A 1995 Norwegian survey found a majority of Australian courses approached 10% management content, but that some had markedly less (Solem, 1998). By 1999 the level of compliance with the 10% rule still varied significantly:

“An analysis of engineering courses shows that the Policy has been applied with enthusiasm by about one-third of the engineering schools, and fairly well in another third, other responses appear to be so ineffectual as to indicate that the educators concerned simply do not get it concerning the nature of modern professional engineering employment.” (Lloyd et al., 2001, 54).

A compounding difficulty in the achievement of the target of 10% management content was (and is) the rapid increase in technical knowledge and the struggle to keep pace with it within a four year undergraduate engineering course, even though undergraduate engineering programs in Australia are typically one year longer in duration than undergraduate programs in most other disciplines, and the weekly contact hours for engineering can be 20%-50% greater than other undergraduate programs (Seethamraju and Agrawal, 1998).

Having a policy is one thing, implementation is another. As the policy on management studies in engineering undergraduate courses was to be phased in, and considering the four-year (minimum) pipeline delay for new engineering students to graduate, it is not surprising that the calls for improvement in preparation of engineering graduates in the area of management skills continued. Also, policies are subject to change over time.

2.5 Recent developments

The 1991 Skills Enhancement Project initiated by the Association of Professional Engineers and Scientists, Australia (APESA) and the Department of Employment,
Education and Training (DEET) examined issues relating to the application of engineering and science in achieving international competitiveness within a framework of sustainable development. The focus of the project was on ‘applicable skills enhancement requirements and opportunities’. The results of the project were published in a 1992 report titled Skills for the Future (Bates et al., 1992). The report reached a similar conclusion to Williams (1988) and others, in that, in relation to undergraduate preparation,

“Australian engineers are well prepared in engineering technology, but not well prepared for the full practice of engineering in its managerial and business dimensions.” (Bates et al., 1992, 9).

It further concluded that:

“The deficiencies identified to Williams by employers are confirmed by critical feedback from young engineers who participated in the project. It is clear that even with recent moves by education providers to increase the proportion of management studies in undergraduate courses, skills in a broad spectrum of management, business, personal and interpersonal areas remains a pressing imperative for most engineering graduates as soon as they join the workforce.” (Bates et al., 1992, 8).

While acknowledging the different requirements of individual professions and enterprises, the report identified a general requirement for additional multi-skilling of engineers and scientists during undergraduate education, and during postgraduate education and training, particularly in the areas of:

- cross-discipline skills - such as computer systems, mathematics, materials, environmental science, etc.;
- practice skills - such as specification and contract management, planning and resource management, heritage and cultural issues, etc;
- business and management skills - such as people management, business management, finance, economics, project management, ethics, law, etc; and
• personal and interpersonal skills - such as leadership, team work, communication, analytical and creative techniques, etc.

The report recommended a reassessment of the balance between undergraduate education and postgraduate education and training. It suggested that these three phases of professional formation should be considered more holistically, in particular, in initial undergraduate education there is a requirement for, “...an appropriate balance of technology and non-technology knowledge and skills.” (Bates et al., 1992, 9).

The 1993 IEAust National Competency Standards for Professional Engineers (Institution of Engineers Australia, 1993) sought to “identify the overall balance of knowledge, skills judgement, ethical standards and experience required by Professional Engineers”. The many objectives of the National Competency Standards include providing a basis for assessing the eligibility for membership of the IEAust, to provide a reference for the development of industry-based competency standards for Professional engineers and to indicate how articulation between the levels of Engineering Associate, Engineering Technologist and Professional Engineer may be achieved. Another stated objective was, “To provide an aid to the design of undergraduate and postgraduate engineering courses intended to prepare candidates for membership [of the IEAust]”. While acknowledging the independence of higher education institutions in determining course structure and teaching methods, the prescriptive nature of the Standards provide strong guidance for course design in all areas of engineering undergraduate course content, including management. The Standards reinforced the IEAust’s requirement for management studies in undergraduate programs.

In 1994 DEET commissioned the Report on the Impact of the Discipline Review of Engineering (Caldwell, 1994). The inquiry’s aim was to determine the impact of the recommendations of the 1988 Williams review. The method of inquiry involved sending a questionnaire based on the recommendations of the Williams review to every Dean of Engineering in Australia. While the recommendations of the Williams review did not specifically address undergraduate management education, amongst
the many results obtained from the survey, it was concluded that developing the ‘communications skills’ of students was given a high priority by institutions, and that some progress had been made.

The inquiry also investigated the impact of a selection of ‘post-Williams’ factors on engineering schools. In this section the inquiry noted that there was ‘quite strong’ endorsement for the 1990 IEAust policy for management education in engineering undergraduate courses, particularly for the requirement for 10% management component in courses. Finally, the inquiry also sought comments on ‘10 major issues identified by Williams’. On the issue of ‘non-technical [management] subjects’, the difficulties in implementing Williams’ recommendations were identified as “Lack of time and resources” and “The development of communication skills requires intensive teaching methods and the reduced funding levels have presented extreme difficulties”. The level of public funding of the higher education sector is likely to continue to be under pressure for the foreseeable future, so any new initiatives need to be designed to be cost effective.

In 1991 the federal cabinet commissioned an investigation into leadership and management in Australian industry. In 1992 the government established the Industry Task Force on Leadership and Management Skills, chaired by David Karpin. In 1995 the task force produced a report (commonly referred to as the Karpin Report) (Karpin, 1995) examining the way Australia prepares its managers for work and leadership, what changes Australia needs to make to ensure that its managers are equipped to compete internationally and recommendations for achieving these changes and their benefits. The main premise of the report is that improved management and leadership skills are central to Australia’s international success.

The report proposed that management and leadership are central to achieving the industrial changes essential for Australia’s success, and that if we are to achieve national success, we must improve the performance of our managers. The report identified five key challenges for Australia in this regard:

1. developing a positive enterprise culture through education and training;
2. upgrading vocational education and training and business support;
3. capitalising on the talents of diversity;
4. achieving best practice management development; and
5. reforming management education.

The report presented 28 policy recommendations based on the task force findings. Within these recommendations were implications for the content of undergraduate management education, particularly engineering and other industry-related disciplines. In particular, recommendation 1 called for the development of an enterprising culture within formal education and training by “expose[ing] students at primary, secondary, vocational and tertiary levels of education to the value of enterprising and entrepreneurial behaviour”. Recommendation 22 called for “state-of-the-art management and leadership educational curricula be developed and disseminated to management education providers and other interested parties”. The report identified ‘remedial’ actions that need to be taken to upgrade the management and leadership skills of Australians already working in these roles, and proposed fundamental and systematic changes to the preparatory education processes to instil the required knowledge and skills in future generations of students. Obviously, undergraduate engineering education has a role to play here.

In 1996 a major review of engineering education in Australia (sponsored by the IEAust, ATSE, ACED and DEETYA) was published (Johnson, 1996a). It made wide ranging recommendations that, if adopted, will revolutionise engineering undergraduate education in Australia. Amongst its many recommendations, the review re-affirmed the requirement for management education, identified the need to introduce flexibility into access and conduct of courses and recognised the likely impact of information technology on engineering undergraduate education in the near future. The review reaffirmed the importance of instilling graduates with an understanding of the context in which engineering functions, including “…economics, finance, accounting, teamwork and competition…” . The review also proposed more freedom for, and scope for innovation by, individual engineering schools in determining their course content and modes of delivery, moving from a prescriptive system of accreditation to one focussing more on demonstrated outcomes and graduate attributes.
In response to the recommendations of the review, the IEAust issued a revised framework for the accreditation of undergraduate courses in 1997 (Institution of Engineers Australia, 1997). The new policy on the accreditation of professional engineering courses contained the following revised course content requirement relating to engineering management:

“...integrated exposure to professional engineering practice (including management and professional ethics). This element should be 10% of the total course content;” (Institution of Engineers Australia, 1997, 4).

There was a perception that the revised policy on engineering management studies was weaker and more ambiguous than the previous 10% rule of 1991:

“Does this mean that this element could be interpreted as 1% management, and 9% professional ethics and other studies?” (Young, 1998, 13).

It became apparent in 1998 that, while the objectives of the new accreditation regime were widely supported, both the engineering schools and the IEAust were experiencing difficulty in implementing the operational requirements of the system. In June 1999 a task force comprising members of the IEAust and ACED was formed to review the accreditation process and devise a workable policy and process for accreditation of undergraduate engineering courses. In October 1999 a revised version of the Accreditation Manual was approved and issued (Institution of Engineers Australia, 1999a). It has been subtly modified to de-emphasise engineering management studies even further:

“...integrated exposure to professional engineering practice (including management and professional ethics). This element should be about 10% of total program content;” (Institution of Engineers Australia, 1999a, 6).

In early 1998 the IEAust undertook a review of its competency standards, the second edition being published in April 1999. The new edition is more comprehensive than
its predecessor, with the competency standards for professional engineer, engineering technologist and engineering associate (officer) included in a single volume. While the new edition still contains references to management competencies for professional engineers, competencies such as business management, project management and engineering operations are now classified as ‘elective’, and the ‘core’ competencies for professional engineers have been reduced to ‘practice’, ‘design’ and ‘self-management’ (Institution of Engineers Australia, 1999b).

2.6 Discussion

The 1996 review of engineering education in Australia will have a significant impact on engineering courses in Australia; some institutions have moved quickly and overtly to implement elements of the review’s recommendations (Parr et al., 1997) (Ayre and Mills, 1997). While the review does reinforce the need for management studies as part of undergraduate engineering courses, its main influence in this area will probably arise from the revised versions of the IEAust policy and procedures for the accreditation of undergraduate courses that it spawned. Another concurrent influencing factor will be the revised IEAust competency standards for professional engineers.

Australia’s ‘10% rule’ has been held in high regard internationally as a benchmark for management studies in engineering undergraduate courses. On the face of it, the changes in these IEAust documents will ‘water down’ the overt references to the importance of engineering management in undergraduate preparation, and replace the explicit 10% rule with a more ambiguous requirement that combines management studies with engineering practice and ethics. While IEAust accreditation policy documents will still list a requirement for management studies in engineering undergraduate courses, the content and scope of such studies will be much more open to interpretation by individual institutions than has been the case since the 1991 ‘10% rule’. The continuing prominence of management studies in Australian undergraduate engineering studies will now largely depend on the belief of those responsible for course design of the importance of management studies for engineering students.
It is noted that the recently released final version of the IEAust’s Manual for the Accreditation of Professional Engineering Courses contains the statement that universities seeking accreditation of professional engineering courses will be required to have in place a quality management system that encompasses, amongst other things:

“Substantial participation by practising professional engineers, and leading employers of engineering graduates, in the engineering school’s forward planning and in its processes for ensuring educational quality, including assessment of graduate performance.” (Institution of Engineers Australia, 1999a, 18).

The historical literature described above shows that practising professional engineers in Australia have been strong advocates for the introduction of management studies into engineering undergraduate courses. If, under the new course accreditation regime, practising professional engineers actually do play a significant role in the development and review of courses, then the inclusion of engineering management studies in undergraduate courses may remain a priority.

Recent international reviews of engineering education re-affirm the importance of engineering management studies in undergraduate courses:

“Engineering Faculties should...emphasize design, problem solving, the impact of engineering on society and the environment, communication, teamwork, leadership and practical experience...” (The Canadian Academy of Engineering, 1993, iii).

Concurring views and reviews from the US and Europe are cited earlier in this chapter (Grinter, 1955) (Working group on lifelong learning and continuing education in engineering, 1998).

Various Australian reviews and reports into engineering education (some of which are identified previously) have reached the same conclusion. One clear indication that management skills remain crucial for engineers post graduation is the number of
engineers that seek postgraduate studies in management. In the United Kingdom 32% of Master of Business Administration (MBA) students are engineering graduates (Hegarty, 1996), this being the most common first degree discipline of MBA students (Gault, 1999). In Australia the largest MBA program is one designed principally for engineers and focussed on the management of technology (Ashenden and Milligan, 1999). The recent Australian review of continuing professional development in engineering identified that while only 3.5% of engineering graduates pursue a higher degree in engineering, the dominant competency chosen for formal postgraduate study is management, with 15% of engineers studying an MBA (Kean, 1997, 12).

Regardless of the internationally recognised importance of management knowledge and skills for engineers, recent policy developments in engineering management education in Australian undergraduate courses appear to be moving in a direction counter to developments of the previous three decades, and toward a reduced importance for engineering management studies. As stated previously, policy is one (albeit important) thing, implementation is another. The following chapter investigates the implementation of the undergraduate engineering management studies policy in Australia from the perspectives of some of the stakeholders in undergraduate engineering management programs.
3 - Perspectives on undergraduate engineering management studies in Australia

3.1 Introduction

This chapter explores the management skills/competencies that should be imparted by an engineering undergraduate course by identifying the management skills/competencies viewed as important by three stakeholder groups relevant to the project. This chapter will present research into the engineering management experiences of Australian academics involved in the design and delivery of engineering management studies, current undergraduate students studying in flexible mode and recently graduated engineering students. Following the presentation of the findings from the three surveys, these results will be compared with each other, and then with similar surveys presented in the international literature. The aim of this chapter is to identify a framework in which to categorise engineering management skills, and rank the relative importance of these categories.

3.2 Survey design and statistical analysis

As required by university ethics procedures, all of the surveys conducted for the project were anonymous and voluntary. To encourage good response rates under these conditions, the questionnaires were kept as simple and straightforward as possible. In fact, the design of the surveys was so simple that factor analysis to identify response clustering was not considered relevant. Where ‘large’ inventory lists were employed, they were designed to cover the wide range of job functions likely to be carried out by the practising engineers and technologists. Removing ‘redundant’ inventory items would likely exclude responses from some respondents. The purpose of the management skills inventory element was to identify broad categories of management skills considered important by the respondents.

Internal reliability analysis requires purposefully redundant questionnaire elements to test that respondents give the same basic response to questions asked in different ways. Having questionnaires longer than necessary was intentionally avoided to improve response rates. No piloting of questionnaires was conducted, as the questionnaires were very simple.
The details of each of the three questionnaires are presented in the following sections. A wide range of data are presented and analysed in the surveys, some of them quantitative and some of them descriptive. Many results are not quantitative, so there is a limit to the statistical analysis that can be performed. For other data there is a limit to the appropriate statistical analysis required for meaningful results. Parametric statistical inference testing is used where it is appropriate. Correlation analysis underlies the identification of many parametric statistical inference tests.

3.3 Australian engineering management academics

While policies from the course accreditation body and other related stakeholder organisations influence the design and execution of engineering management education, a critical factor in the implementation and delivery of engineering management studies is the academic staff with the responsibility for the design and conduct of these studies. To gain an appreciation of the backgrounds, beliefs, qualifications and experience of engineering management academics in Australia, the author conducted a survey of this group in April 1998. From this exercise the management skills believed to be important by this stakeholder group were identified.

3.3.1 Methodology

At the time of the survey, 93 separate academic units (faculties, departments and schools) were found to be offering one or more engineering undergraduate courses in Australia. The heads of all of these academic units were contacted with the request that they nominate appropriate academic staff members (regardless of the discipline area within the university that they belonged to and regardless of their status as full-time, part-time or adjunct staff) to receive the survey. A copy of the survey package is included in Appendix A - Questionnaire sent to Australian engineering management academics. Responses were received from 59 of the identified academic units – a response rate of 63.4%. The list of nominated recipients was supplemented by identifying other Australian academics actively publishing in the field; sources consulted included all recent conference proceedings of the Australasian Association for Engineering Education (AAEE), the UNESCO
International Centre for Engineering Education (UICEE) and the Australasian Conference of Engineering Management Educators (ACEME).

A total of 146 potential individual participants were identified and surveyed via post. The survey included a reply-paid envelope so respondents could return the submission at no cost. As required by the university research ethics approval for this project, participation in the survey was anonymous and voluntary. The survey sought information under the following categories:

- demographic information - age; gender; qualifications; work experience;
- understanding of engineering management;
- important management skills/competencies; and
- views on engineering management education.

3.3.2 Results
Responses were received from 57 participants. 16 of those respondents indicated that they were ‘not the appropriate person’ to complete the survey, indicating that more than 10% of potential respondents were inappropriately identified by the head of their academic unit! The remainder of valid responses was 41, or 31.5% of the identified qualified potential respondents.

The mean respondent age was 46.7 years, with a standard deviation of 9.9 years. The range of respondent ages was 31 to 77 years. The median respondent age was 46 years. 87.8% of respondents were male, 12.2% were female.

Table 3 shows the percentage of respondents holding a technical qualification. Note that in Australia a ‘Diploma’ qualification represents a sub-Bachelor award; for example, in engineering, a Bachelor of Engineering is a four-year award, and a Diploma of Engineering was a three-year award that existed prior to 1980. A ‘Graduate Diploma’ is a post-Bachelor award, normally by coursework, taken to broaden or deepen the academic experience of the candidate.

Table 3 also shows the distribution of technical qualifications found in the general population of Australian engineering academics (Anderson et al., 1997), and that it
Table 3 - Percentage of respondents holding either a technical or management qualification, compared to the percentage of technical qualifications held by Australian engineering academics

<table>
<thead>
<tr>
<th>Qualification</th>
<th>Technical (Respondents)</th>
<th>Technical (General Australian)</th>
<th>Management (Respondents)</th>
</tr>
</thead>
<tbody>
<tr>
<td>No Degree</td>
<td>4.9 %</td>
<td>-</td>
<td>61.0 %</td>
</tr>
<tr>
<td>Diploma</td>
<td>2.4 %</td>
<td>-</td>
<td>0.0 %</td>
</tr>
<tr>
<td>Bachelor</td>
<td>14.6 %</td>
<td>9.5 %</td>
<td>12.2 %</td>
</tr>
<tr>
<td>Graduate Diploma</td>
<td>2.4 %</td>
<td>-</td>
<td>9.8 %</td>
</tr>
<tr>
<td>Master</td>
<td>19.5 %</td>
<td>18.2 %</td>
<td>12.2 %</td>
</tr>
<tr>
<td>Doctorate</td>
<td>56.1 %</td>
<td>68.0 %</td>
<td>4.9 %</td>
</tr>
<tr>
<td>Other</td>
<td>-</td>
<td>4.3 %</td>
<td>-</td>
</tr>
</tbody>
</table>

does not depart significantly from the respondent group. Table 3 also shows the percentage of respondents holding a management qualification. Table 4 summarises the years of experience the respondents have had working in the engineering workforce, working in a management capacity and working in a lecturing/teaching capacity. The median values reported demonstrate significant practical experience in technical, management and educational areas amongst Australian engineering academics.

Table 4 - Years of experience of respondents working in engineering, management and education

<table>
<thead>
<tr>
<th>Field</th>
<th>Mean</th>
<th>Std Dev</th>
<th>Minimum</th>
<th>Maximum</th>
<th>Median</th>
</tr>
</thead>
<tbody>
<tr>
<td>Engineering</td>
<td>14.3</td>
<td>13.5</td>
<td>0</td>
<td>54</td>
<td>10</td>
</tr>
<tr>
<td>Management</td>
<td>10</td>
<td>8.9</td>
<td>0</td>
<td>40</td>
<td>8</td>
</tr>
<tr>
<td>Education</td>
<td>11.7</td>
<td>8.7</td>
<td>0.25</td>
<td>35</td>
<td>9</td>
</tr>
</tbody>
</table>

As stated previously, the 1991 IEAust document Guidelines for Management Studies in Engineering Undergraduate Courses provides a model undergraduate engineering
management curriculum composed of 17 modules of study. This model curriculum is summarised above in Table 2. Respondents were asked to rate their perceived importance of each of these 17 elements on a three-point scale of not important, important and very important. Figure 2 shows the results. The mean response and the standard deviation for each of the 17 elements are given (on the basis that a response of not important = 1, important = 2 and very important = 3).

Respondents were asked to list any other management skills they considered necessary for engineers. These additional skills and the frequency with which they were reported are listed in Table 5.

![Bar chart showing perceived importance of management skills](image)

**Figure 2 - Perceived importance of management skills**

Respondents were asked, ‘whether the most important phase for engineering management education was undergraduate, postgraduate or both?’ 12.5% of
Table 5 - Other management skills identified as important (frequency mentioned in parenthesis)

<table>
<thead>
<tr>
<th>Skill</th>
<th>Frequency</th>
<th>Additional Skills</th>
<th>Frequency</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time management</td>
<td>(5)</td>
<td>R&amp;D management</td>
<td>(1)</td>
</tr>
<tr>
<td>Teamwork</td>
<td>(3)</td>
<td>System dynamics</td>
<td>(1)</td>
</tr>
<tr>
<td>Technology management</td>
<td>(3)</td>
<td>Information technology</td>
<td>(1)</td>
</tr>
<tr>
<td>International business</td>
<td>(3)</td>
<td>Systems approach</td>
<td>(1)</td>
</tr>
<tr>
<td>Industrial relations</td>
<td>(3)</td>
<td>Public relations</td>
<td>(1)</td>
</tr>
<tr>
<td>Cross-discipline interaction</td>
<td>(2)</td>
<td>Maintenance management</td>
<td>(1)</td>
</tr>
<tr>
<td>Ethics</td>
<td>(2)</td>
<td>Environmental management</td>
<td>(1)</td>
</tr>
<tr>
<td>Decision making</td>
<td>(2)</td>
<td>Strategic management</td>
<td>(1)</td>
</tr>
<tr>
<td>People skills</td>
<td>(2)</td>
<td>Cost estimating</td>
<td>(1)</td>
</tr>
<tr>
<td>Change management</td>
<td>(2)</td>
<td>Risk management</td>
<td>(1)</td>
</tr>
<tr>
<td>Lifelong learning</td>
<td>(2)</td>
<td>Media relations</td>
<td>(1)</td>
</tr>
<tr>
<td>Networking</td>
<td>(1)</td>
<td>Management of design</td>
<td>(1)</td>
</tr>
<tr>
<td>Supply management</td>
<td>(1)</td>
<td>Contract management</td>
<td>(1)</td>
</tr>
<tr>
<td>Dealing with customers</td>
<td>(1)</td>
<td>Cost control</td>
<td>(1)</td>
</tr>
<tr>
<td>Negotiation</td>
<td>(1)</td>
<td>Cybernetics</td>
<td>(1)</td>
</tr>
<tr>
<td>Logic</td>
<td>(1)</td>
<td>Report writing</td>
<td>(1)</td>
</tr>
<tr>
<td>Problem definition</td>
<td>(1)</td>
<td>Forecasting</td>
<td>(1)</td>
</tr>
</tbody>
</table>

respondents indicated that the undergraduate phase was the most important, 12.5% of respondents indicated that the postgraduate phase was the most important and 75% of respondents indicated that both the undergraduate and postgraduate phases were important. Almost 90% of respondents indicated their belief that engineering management education should be included in undergraduate studies.

3.3.3 Discussion
It was not feasible to discover the demographic characteristics of the sample population and, hence, make a comparison with the demographic characteristics of the respondent sample population, and therefore to be able to comment on the validity of inferences made from the sample population. But, as will be seen in following sections, some support is given to the results obtained here by the fact that
they are consistent with the two related surveys also reported as part of this project, as well as the a range of similar international surveys found in the literature.

Based on the mean ratings presented in Figure 2, respondents ranked the elements of management competency in the following order of importance; Communication skills, Project management, Supervision and leadership, Economic evaluation of projects and Operations and quality management. Of the five elements listed above, none scored less than a 2.5 rating. Examining the five elements ranked highest, it appears that these skills are identified as being ‘part of engineering’ (ie. Project management, Operations and quality management and Economic evaluation of projects) or important generic professional practice skills (ie. Communication skills and Supervision and leadership). The first five, highest ranked elements are highly practical, action-oriented activities that members of the engineering workforce may be involved in on a regular basis.

For the remaining skills, support was less strong and/or more equivocal, though the fall-off in ranking is relatively small across all of the questionnaire competency elements; all of the mean respondent rankings falling within a range of 1.1.

Continuing on from above, the list in order of decreasing mean rating was Organisational behaviour, Human resource management and Innovation. These three competency elements appear to fall in a mid-range ranking group between the first group of five and the remainder of the competency elements, though they could arguably be included in the ‘highly ranked’ group. These three elements are all important for organisational success, and perhaps represent important generic ‘management’ skills identified by a lesser proportion of respondents who have held more senior or more general management positions.

The remainder of the list in order of decreasing mean rating was Engineering and society, Business strategies, Legal studies, Finance, Accounting, Economics, Marketing, Theories of management and, finally, Management science. From this second list it could be suggested that the lower rating of these particular management skills is due to the more theoretical nature of the topics (ie. Engineering and society,
Management science, etc) or that they are closely identified with other (non-engineering) professions/business functions (ie. Legal studies, Marketing, Accounting, etc).

Table 3 reveals that more than 60% of those academics involved in the delivery of engineering management studies (regardless of whether their originating discipline area is engineering, management or elsewhere) have no management qualifications at all. This is a factor for concern. If (as the literature suggests) the acquisition of formal management qualifications is so important for practising engineers, it must be even more so for those academics involved in the design and delivery of engineering management study programs. While experience of the practice of engineering management is valuable in contextualising management studies, academic rigour in the discipline area should be considered a fundamental prerequisite for those in educational roles.

The research cited above indicates that while more than 86% of Australian engineering academics hold a technical qualification of Master level or greater (Anderson et al., 1997), barely 17% of Australian academics involved in undergraduate engineering management education hold a management qualification of Master level or greater. There appears to be a strong and pressing need for Australian academics involved in engineering undergraduate management education (irrespective of whether their discipline area is technology or management) to upgrade their academic qualifications in the field of management.

While adequacy of academic qualifications might be considered a prerequisite, consideration should also be given to the relevance and currency of knowledge and experience of academic staff involved in undergraduate engineering management education. The rapid advancement of both engineering and management knowledge is well documented (Bailey, 1996) (Anfuso, 1999), so it can be expected that even the most current academic qualifications will need to be refreshed over time. Academics involved in undergraduate engineering management education need to seek exposure to current engineering and technology management practices to inform and advance their scholarship. One approach is periodic placement in industry
(Beatty et al., 1996). Another option is collaborative research projects with industrial partners. One beneficial aspect of interaction with mature age students, noted later, is that they may bring to their studies (and their interactions with academic staff) current experience of engineering management practices in industry.

The subject area of engineering management, by its nature, incorporates an intersection of technology and management. One possible option (that is employed by many engineering schools) for the injection of academic rigour while at the same time maintaining an engineering context for management studies is the joint development and/or delivery of these study programs by academic staff from both engineering and management/business faculties.

In a recent engineering education research project incorporating a literature review and survey of 756 practising Australian engineers, Seethamraju and Agrawal (1998) identified that undergraduate students do not appear to be convinced that non-technical subjects are relevant to their concerns, and do not appear to see the connection between technical and non-technical subjects. 65% of their survey respondents indicated that they did not realise the importance of non-technical subjects while they were studying. The survey results point to this student disinterest arising from the general weakness of multidisciplinary teaching, the processes adopted in teaching non-technical subjects and poor cooperation/understanding between academic staff from engineering and business/commerce faculties. Seethamraju and Agrawal conclude:

“...an increase in the non-technical content of their undergraduate curriculum may in itself not achieve the desired outcome of improved ‘soft’ skills among engineers. It is essential to create an awareness of their importance among engineering students and to encourage an interest in those subjects by modifying the educational processes.” (Seethamraju and Agrawal, 1998, 41).

The idea that the presentation on non-technical studies needs to be tailored to the ‘characteristics’ of engineering students is also reported elsewhere (Silyn-Roberts, 1998). Relevance of management in engineering practice must be paramount, and
any temptation to completely ‘hand over’ the management content of engineering undergraduate courses to service teaching from management faculties should be resisted. Most engineering undergraduates are likely to take some time to appreciate the importance and relevance of management to engineering practice, and the presentation of management studies in a manner that is theoretical and abstracted from the context of real engineering practice can do nothing but extend this period further.

The list of additional skills given by respondents in Table 5 includes many that could be viewed as attributes or components of those already listed in Figure 2, although this is open to individual interpretation. What can be concluded with certainty is that the range of skills identified by respondents confirms that engineering managers require capabilities beyond the mere management of technology and the engineering function in isolation, and that the engineering manager is faced with the same wide range of issues and concerns involved in the management of any aspect of an organisation. Very few, if any of the skills identified could be said to relate to the domain of engineering or technology exclusively, and many of them are generic professional skills required for effective operation in management/leadership roles in an organisation.

The clustering of respondent rankings (as observed in Figure 2) and the wide range of skills identified as important by respondents will be noted again and discussed further in the remainder of this chapter.

87.5% of respondents indicated that management studies should be included in the undergraduate preparation of engineers. The same proportion (though not all the same respondents) indicated that management studies were appropriate at the postgraduate level. The issue of where management studies are most appropriately situated in the career of the engineer is addressed in Chapter 7.

Engineering management academics provide an institutional perspective on engineering management studies and those management skills viewed as important. Flexible delivery is another of the key elements in this project, and in the context of
flexible delivery there is another stakeholder group who has an important position. The original justification for flexible delivery of education was to open up educational opportunities to groups unable to participate in conventional on-campus studies. In the context of engineering, the principal beneficiary group of flexible delivery are off-campus students seeking qualifications in engineering and related professional disciplines. For this project, these students provide a valuable perspective on those management skills viewed as important. The following section investigates undergraduate engineering management studies from their perspective.

3.4 Engineering management studies as part of continuing engineering education

With the introduction of engineering and technology degrees via flexible delivery, there are a growing number of mature age engineering students returning to study to upgrade their qualifications. These students offer a new and unique perspective on engineering management - they may have had significant practical experience as a manager/supervisor in an engineering environment. Engineering programs aspiring to offer flexibility and/or cater for mature age students must consider and address the specific needs of this student body. This section reports on a survey undertaken to better understand the perceptions of mature age engineering students relating to engineering management.

As discussed previously, the Australian review of engineering education (Johnson, 1996a) proposed more freedom for, and scope for innovation by, individual engineering schools in determining their course content and modes of delivery, moving from a less prescriptive system of accreditation to one focussing more on demonstrated outcomes and graduate attributes. As well as new opportunities for flexibility, there are also drivers for change and increased flexibility coming from other directions. Australia now has a well established culture of life long learning (Allen, 1996) that has arisen through the need to re-equip people with new skills as part of organisational programs of continuous improvement and total quality management. It is unrealistic to expect organisations to release staff to attend full-time, on-campus study; engineering programs need to cater for mature-age students in the workplace who are upgrading their qualifications and skills. To achieve more
flexibility and appropriate outcomes, many engineering organisations worldwide are currently establishing links with engineering Schools to provide their staff with customised, flexible programs delivered into their workplaces (Seaman, 1997) (Haynes et al., 1997).

Arising from the introduction of engineering and technology degrees via flexible delivery, there are a growing number of mature age engineering students returning to study to upgrade their qualifications (Klus, 1995) (Lloyd et al., 1996) (Kulandaisswamy and Mandke, 1995). The majority of these students have previously studied and/or worked in the engineering workforce. Recognition of prior learning (RPL) plays a central role in flexible teaching and learning. In engineering education it is an essential part of creating pathways for engineering associates to articulate to higher occupational categories. Models of RPL exist that permit block credit of up to half of an engineering degree (Lloyd et al., 1995).

The reasons why mature age students return to engineering studies, their motivations, the differences between them and their younger, conventional counterparts and their particular learning requirements are seldom reported (Dingle, 1997). These students offer a new and unique perspective on engineering management. They may have had significant practical experience as a manager/ supervisor in an engineering environment (Palmer, 1998) and may have worked under the supervision of an engineering manager, while, at the same time, their view of engineering management comes from outside of formal membership of the profession and completion of the engineering undergraduate education process. To better understand the perceptions of mature age engineering students relating to engineering management, a survey was conducted in April 1998, the details and results of which are described here.

3.4.1 Methodology
For the purposes of this research a mature age student is defined as being aged 20 years or greater at the commencement of their engineering studies (Briggs, 1995). Prior research in the Deakin University School of Engineering and Technology has shown that mode of study is a strong predictor of whether a student is mature age or not; off-campus students are almost exclusively mature age (Briggs, 1995). As it was
impractical to identify the age of individual students, but straightforward to produce contact information for students based on their mode of study, it was decided to use mode of study as a proxy characteristic for selection of students as potential survey respondents. A questionnaire was developed to collect information from off-campus students in the following categories:

- general demographic information;
- perceived importance of various management competencies/skills; and
- descriptive information relating to engineering management experiences.

The questionnaire was sent via post to 100 randomly selected off-campus engineering and technology students enrolled at Deakin University, and the results of the survey exercise are presented here. A copy of the survey package is included in Appendix B - Questionnaire sent to mature age engineering students. This survey is not definitive in its representation of mature age engineering students, as convenience sampling was used in restricting the sample population to off-campus, Deakin University students only. As required by the university research ethics approval for this project, participation in the survey was anonymous and voluntary.

3.4.2 Results
From the 100 questionnaires sent to off-campus students, 28 were returned. Compared to end-of-semester unit evaluation surveys that Deakin University off-campus students also return via post on a voluntary basis, the response rate of 28% is favourable. Of the 28 returned, 27 were from students meeting the criteria for being classified as mature age. The following data and discussion is based on the returns from ‘mature age’ students only.

The mean age of respondents was 32.9 years, with a standard deviation of 6.4 years and a range of 20 years to 52 years. 81.5% of respondents were male, and 18.5% were female, this compares with female student participation in the general Australian engineering undergraduate population of approximately 15% (extrapolated from (Roberts and Lewis, 1996)). Figure 3 shows the proportions of previous highest qualification reported by the respondents.
Figure 3 - Proportions of previous highest qualifications reported by respondents

As stated previously, the 1991 IEAust document Guidelines for Management Studies in Engineering Undergraduate Courses provides a model undergraduate engineering management curriculum composed of 17 modules of study (see Table 2). Respondents were asked to rate their perceived importance of each of these 17 elements on a three-point scale of not important, important and very important. Figure 4 shows the results in graphical form. The mean response and the standard deviation for each of the 17 elements are given (on the basis that a response of not important = 1, important = 2 and very important = 3).

Respondents were asked to identify any other areas of management competency/skill that they considered important for professional engineers. Only 12 responses were received in this section (see Table 6).

Respondents where asked to list/describe any prior experience in management/supervision roles. 77.8% of respondents indicated prior management roles/experience. This lends weight to the proposition that many mature age engineering students have experience not only of the engineering workforce generally, but also in management roles. Table 7 summarises all responses received and demonstrates that a majority of the management experience reported by respondents relates to the engineering workforce.
Figure 4 - Perceived importance of management skills as reported by respondents

Table 6 - Other management competencies identified as important

<table>
<thead>
<tr>
<th>Psychology / human motivation</th>
<th>Evaluation of environmental costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>Staff motivation</td>
<td>Workshop practice</td>
</tr>
<tr>
<td>Competition</td>
<td>Commerce</td>
</tr>
<tr>
<td>Conflict resolution</td>
<td>Time management</td>
</tr>
<tr>
<td>OH&amp;S</td>
<td>Logistics</td>
</tr>
<tr>
<td>Creativity</td>
<td>Information technology (IT) management</td>
</tr>
</tbody>
</table>

3.4.3 Discussion
Referring to Figure 3 above, in Australia the national secondary school certificate is known variously as the Higher School Certificate (HSC), Victorian Certificate of
Table 7 - Prior management/supervision experience reported by respondents

| Supervision of unskilled labour | Drafting supervisor |
| Supervision of technical staff | Site supervisor for construction of new plant |
| Manage priority and completion of maintenance jobs | Management in the hospitality industry |
| Supervision of site installation | Supervision of SMT facility |
| Supervise juniors in a retail department | Area manager for computer service company |
| Management of engineering projects | Team leader |
| Supervision of trade staff | Project manager |
| Senior technician – supervising apprentices & junior trades | Training and development of engineering staff |
| Production supervision | Team leader for a cosmetic company |
| Planning and supply management | Factory QA manager |
| Project manager for commissioning new production line | Supervision of labourers |
| Manager of company waste initiative | Supervision of engineering sub-department |
| Supervisor of water treatment plant | First line supervisor |
| Construction manager | Manage 100 trade and technical staff |
| Manager of division of chemical manufacturer | Manage production department |
| Managed educational programs | Manage contract maintenance division |
| Service manager in mechanical workshop | Workshop manager |
| Manage project to market civil engineering internationally | Training laboratory staff |
| Project manager for commissioning new production line | Manager of hydrographic team (10 people) |

Education (VCE) and other similar titles. The vocational and trade education sector is known as Technical and Further Education (TAFE). In Figure 3 above, the normal hierarchy of qualifications is HSC/VCE, trade qualification (now equal with) TAFE certificate/advanced certificate, TAFE diploma and university qualification.

The equal most frequent previous highest academic qualification reported was a high school certificate or a TAFE certificate. Combined, all TAFE awards accounted for 61.5% of prior qualifications. Reported prior work experience in the engineering workforce varied widely, with a mean of 8.4 years, a standard deviation of 8.1 years and a range of zero years to 35 years. 22.2% of respondents indicated no prior experience of the engineering workforce.

Engineering programs incorporating flexible learning and RPL mean that a significant proportion of the students enrolled in a class may be mature-age and may have many years of experience working in the engineering workforce, including extensive practical experience in technical and management areas. It is not
uncommon for mature-age students to possess more knowledge and practical experience than their academic counterpart in particular subject areas. Engineering students with practical experience of the ‘real world’ are more than happy to highlight deficiencies, simplifications and other shortcomings in undergraduate study materials. The maturity and practical experience of mature-age students needs to be acknowledged and catered for; they are looking for knowledge and skills that will underpin their current practice with theory, and that they can apply in their workplace (Palmer, 1999).

Referring to Figure 4 above, none of the competency elements scored a rating less than 1.81. This is not a surprising result as the listed elements are those presented in the Institution of Engineers, Australia (IEAust) guidelines for management studies, a list presumably already subjected to scrutiny to identify important management skills. An important consideration in the interpretation of these results is that the questionnaire respondents were presented only with the brief subject titles as given in Figure 4 above, and it was on this basis, with no further explanation about the content of the subject area, that they made their judgement about the importance or otherwise of the subject area.

Based on mean rating, respondents ranked the elements of management competency in the following order of importance; Communication skills, Project management, Supervision and leadership, Economic evaluation of projects, Innovation, Operations and quality management, and Human resource management. Of the seven elements listed above, none scored less than a 2.5 rating, none had a standard deviation greater than 0.57 and only Human resource management registered a single rating of not important. These results suggest that there is relatively strong agreement that these skills are considered important. These results are also consistent with the results obtained in the previous survey, suggesting that the most highly ranked elements are identified as being ‘part of engineering’ or important generic professional practice skills that trade and para-professional members of the engineering workforce may be involved in on a regular basis.
For the remaining skills, support was either less strong and/or more equivocal (larger standard deviation in result). Continuing on from above, the list in order of decreasing mean rating was Business strategies, Organisational behaviour, Theories of management, Engineering and society, Management science, Finance, Economics, Legal studies, Marketing and, finally, Accounting. As with the results obtained in the previous survey, it could be suggested that the lower rating of these particular management skills is due to the more theoretical nature of the topics or that they are closely identified with other (non-engineering) professions/business functions.

A surprising result was the relatively low rating given to Engineering and society; while it did not score the lowest mean rating, it did generate the widest spread of opinion (SD = 0.71) and received the second highest proportion of not important ratings (22.2%). Given that lack of appreciation of the societal context of science and technology is a common criticism of the profession, this result is of concern and suggests that the development of an understanding of the interactive nature of technology and society is critical for mature age students, as well as conventional entry undergraduate students.

Referring to Table 6, it can be suggested that many of these competencies can be included under the 17 broad headings presented previously, ie.:

- Psychology / human motivation can be considered part of Organisational behaviour, Supervision and leadership and Human resource management;
- Staff motivation can be considered part of Organisational behaviour, Supervision and leadership and Human resource management;
- Commerce can be considered as the combination of Economics, Accounting, Finance, etc;
- Competition can be considered part of Business strategies;
- Time management can be considered part of Operations and quality management and Supervision and leadership;
- Conflict resolution can be considered part of Organisational behaviour, Supervision and leadership and Human resource management;
- Logistics can be considered part of Operations and quality management;
• OH&S can be considered part of Engineering and society, Human resource management and Operations and quality management; and
• Creativity can be considered part of Innovation.

Competencies/skills that are not clearly included in the 17 elements given above include:
• Workshop practice: important in some areas of professional practice, but not really part of engineering management;
• IT Management: a new and important skill for all technology professionals; and
• Evaluation of environmental costs: again, an area of emerging importance related to the concepts of sustainable development, green accounting and environmental management systems.

Even though many of these additional competencies may already be covered in the IEAust’s 17 element model, most of them are very practical and pragmatic engineering management skills that mature age engineering students may already be carrying out as members of the engineering workforce and/or observe as being, or potentially being, valuable in their workplace and/or observed as lacking in some of the practising professional engineers that they currently work with. Written comments provided by respondents suggest that many of them were working, or have worked, under the supervision of professional engineers, and it has been reported that those working under the supervision of professional engineers often note that as engineers become supervisors/managers any deficiencies in their human/interpersonal skills become apparent (Skiris, 1999). Even though some of the comments received from the respondents regarding their engineering supervisors were not positive, the respondents (by implication of their study choice) still aspire to be professional members of the engineering workforce.

It is interesting to note that none of the respondents identified international skills (ie. a second language, cross cultural awareness, international business operations, etc) as important; perhaps due to the fact that most of the respondents are still studying for their first professional qualification and are unlikely to hold senior management positions.
Due to the limited, convenience sample population, this survey cannot claim to be definitive and the results cannot claim wide generalisation. However, the results do provide an insight into the perceptions, views and experiences of mature age engineering students regarding engineering management. Mature age engineering undergraduate students vary widely in age, previous academic qualifications and years of experience in the engineering workforce. These students may bring to the learning environment significant experience of engineering practice, including experience of management in the engineering workforce. This experience can be a valuable addition that enriches the learning environment for both students and academics. This experience needs to be acknowledged and catered for; mature age students are looking for knowledge and skills that will underpin their current practice with theory, and that they can apply in their workplace.

The context of flexibility employed in this project (to be discussed further later) is one of inclusivity, encompassing both on- and off-campus students; a flexible study program is one that caters for both students groups, providing equity in content, processes and outcomes. Graduates of a flexible study program represent this concept of ‘diverse equity’; the graduates have equity of academic qualification, along with diversity of background and experience. Ultimately, an undergraduate engineering management studies program must provide utility to all graduates as they enter the engineering workforce, regardless of their previous backgrounds. Hence, it was considered essential to also survey recent graduates (in all their diversity) of the Deakin engineering programs to ascertain what management skills had been important to them in their practice, as well as determine how well the current flexible delivery program had prepared them for management activities in the engineering workforce. The following section reports on this survey, and then offers a comparison of the findings of the three stakeholder surveys undertaken, as well as relating these findings to similar surveys documented in the international literature.
3.5 Evaluation of undergraduate engineering management studies at Deakin University

The new Deakin School of Engineering and Technology commenced student enrolments in 1993 and offers three year Bachelor of Technology (BTech), four year Bachelor of Engineering (BE), Masters and Doctoral engineering programs in flexible delivery mode. The undergraduate programs are delivered in both on-campus and off-campus modes. Conventional entry students would normally undertake these programs on-campus, full-time; with some of these students taking part or all of their studies part-time and/or off-campus in later years to better suit the employment or other personal circumstances. Mature age students may study the programs on-campus, full-time, but many elect to study off-campus and/or part-time because of employment commitments. In each year of the undergraduate programs, there is one unit out of eight (12.5%) devoted to ‘engineering management’ content. Table 8 provides a broad outline of the current syllabus of each unit – note that the fourth level unit is not a core unit for students studying the three year BTech course, though a small number study it as an elective to increase the management content of their course.

The aim of the survey of recent graduates was specifically to determine their perceptions of the current management studies syllabus, and to identify what management skills had proven to have been valuable in their professional practice.

3.5.1 Methodology

Using the university student information database, graduates from the years 1996 (first graduates of the new School of Engineering and Technology at Deakin University) to 1999 were identified, including both BE and BTech students. These students were sent the survey by post in October 1999, using their last recorded address. A copy of the survey package is included in Appendix C - Questionnaire sent to recent Deakin engineering and technology graduates. The survey included a reply-paid envelope so students could return their response at no cost. As required by University research ethics procedures, participation in the survey was anonymous and voluntary. The survey sought information under the following categories:
Table 8 - Outline of current undergraduate management syllabus

<table>
<thead>
<tr>
<th>Year level and unit</th>
<th>Syllabus outline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Year 1</td>
<td>• Communication skills</td>
</tr>
<tr>
<td>Fundamentals of Technology Management</td>
<td>• Technology perspectives</td>
</tr>
<tr>
<td></td>
<td>• Introduction to management concepts</td>
</tr>
<tr>
<td></td>
<td>• Quality management concepts</td>
</tr>
<tr>
<td>Year 2</td>
<td>• Systems concepts for engineers and technologists</td>
</tr>
<tr>
<td>Managing Industrial organisations</td>
<td>• Managing people in organisations</td>
</tr>
<tr>
<td></td>
<td>• Manufacturing and environment</td>
</tr>
<tr>
<td></td>
<td>• Occupational health and safety</td>
</tr>
<tr>
<td>Year 3</td>
<td>• Project management</td>
</tr>
<tr>
<td>Methods of Managerial Decision Making</td>
<td>• Accounting and financial management</td>
</tr>
<tr>
<td></td>
<td>• Operations research</td>
</tr>
<tr>
<td>Year 4</td>
<td>• Technological forecasting and assessment</td>
</tr>
<tr>
<td>Strategic Issues in Engineering</td>
<td>• Policy design in engineering organisations</td>
</tr>
<tr>
<td></td>
<td>• Issues in productivity improvement</td>
</tr>
</tbody>
</table>

- demographic information — age; gender; study mode;
- experience in engineering practice;
- experience in management roles;
- identifying management skills that have been important in practice; and
- evaluating the effectiveness of the management stream in the Deakin undergraduate engineering program.

Based on the 17 unit model syllabus from the IEAust Guidelines for Management Studies in Engineering Undergraduate Courses (Institution of Engineers Australia, 1991b), (as presented in Table 2) and supplemented by results obtained from the two prior surveys of mature age engineering students and Australian engineering management academics, (both presented earlier in this chapter) a 45 item management skills inventory was developed (see Table 9) and respondents were asked to indicate which of these management skills had been important to them in their professional practice since graduation.
Table 9 - Management skills inventory used by survey respondents

<table>
<thead>
<tr>
<th>Communication skills</th>
<th>Project management</th>
<th>Legal / law</th>
</tr>
</thead>
<tbody>
<tr>
<td>Supervision &amp; leadership</td>
<td>Accounting &amp; finance</td>
<td>Economics</td>
</tr>
<tr>
<td>Quality management</td>
<td>Professional ethics</td>
<td>Marketing</td>
</tr>
<tr>
<td>Organisational behaviour</td>
<td>Operations management</td>
<td>Business strategies</td>
</tr>
<tr>
<td>Project evaluation</td>
<td>Human resource manage.</td>
<td>Theories of management</td>
</tr>
<tr>
<td>Teamwork</td>
<td>Lifelong learning</td>
<td>Systems approach</td>
</tr>
<tr>
<td>Time management</td>
<td>Public relations</td>
<td>Maintenance management</td>
</tr>
<tr>
<td>International business</td>
<td>Strategic management</td>
<td>Cost estimation</td>
</tr>
<tr>
<td>Risk management</td>
<td>Environmental manage.</td>
<td>Industrial relations</td>
</tr>
<tr>
<td>Design management</td>
<td>Supply management</td>
<td>Change management</td>
</tr>
<tr>
<td>Dealing with customers</td>
<td>Decision making</td>
<td>Negotiation</td>
</tr>
<tr>
<td>Report writing</td>
<td>Contract management</td>
<td>Forecasting</td>
</tr>
<tr>
<td>Motivation</td>
<td>Competition</td>
<td>Conflict resolution</td>
</tr>
<tr>
<td>Occupat. Health &amp; safety</td>
<td>Creativity</td>
<td>Information management</td>
</tr>
<tr>
<td>Logistics</td>
<td>Inventory management</td>
<td>Work/time study</td>
</tr>
</tbody>
</table>

3.5.2 Results

3.5.2.1 Response rate
From a total of 135 graduates from the period 1996 to 1999, 20 surveys were returned as not deliverable. From the remaining 115 potential respondents, 42 completed questionnaires were received, a voluntary response rate of 36.5%.

3.5.2.2 Demographic information
The age range of respondents varied widely (23 – 54 years), with a mean of 30.2 years and standard deviation of 7.4. The proportion of female respondents was 19.0%; the proportion of male respondents was 81.0%. The proportion of on-campus students was 71.4%; the proportion of off-campus students was 28.6%. The breakup of the engineering disciplines studied by the respondents was: Manufacturing – 57.1%, Environmental – 26.2% and Mechatronics – 16.7%. 40.5% of respondents had obtained a BTech qualification, while 59.5% has obtained a BE qualification.

3.5.2.3 Experience in engineering practice
The years of work experience since graduation reported by the respondents varied from 0 – 6 years, with a mean of 2.2 years and a standard deviation of 1.4. The
employment sectors reported by the respondents covered a wide range, including public sector, private industry, manufacturing, IT, consulting, building, education and postgraduate studies. The job functions reported by the respondents covered a wide range, including director, lecturer, manager, designer, project manager and research and development.

3.5.2.4 Experience in management roles
The range of specific management roles reported as held by respondents is given in Table 10. Where a management role was reported more than once, the frequency is given in parentheses.

Table 10 - Management roles reported as held by respondents

| Supervisor (13) | Project manager (19) | Team leader (9) |
| Business unit manager | Maintenance manager | Assistant site supervisor |
| Head draftsperson | Director | Business devel. manager |
| Engineering manager | Region. envir. manager (2) | Production manager |
| Area manager | Student representative | Supervisor for trades |
| | | |

3.5.2.5 Management skills that have been important in practice
Figure 5 shows the frequency with which respondents indicated that particular management skills had been important/relevant to them in their experience of professional practice since graduation.

The following additional skills were identified by respondents as being important to them: capital expenditure justification, marketing of services, empathy, organisational skills, scheduling, interpersonal interaction across the organisational hierarchy and coaching.

3.5.2.6 Effectiveness of the management stream in the Deakin undergraduate engineering program
Respondents were asked to evaluate the effectiveness of their undergraduate management studies. For a number of statements regarding their management studies, respondents were asked to indicate their agreement or otherwise using a five-point Likert style scale. Table 11 shows the results; the mean agreement rating and
Figure 5 - Importance/relevance of management skills as identified by respondents
Table 11 - Respondent evaluation of effectiveness of undergraduate management studies

<table>
<thead>
<tr>
<th>Statement regarding management studies</th>
<th>Mean rating</th>
<th>Std. dev.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Overall, the engineering management component of your undergraduate studies has been of value to you</td>
<td>3.8</td>
<td>1.0</td>
</tr>
<tr>
<td>If you entered engineering directly from secondary school, your management studies helped prepare you</td>
<td>3.5</td>
<td>1.1</td>
</tr>
<tr>
<td>for real engineering practice</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you entered engineering as a mature age student, your management studies helped formalise your</td>
<td>3.9</td>
<td>1.2</td>
</tr>
<tr>
<td>understanding of management gained from your prior work experience</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you studied principally on-campus as an undergraduate, your classroom activities and assessment</td>
<td>3.4</td>
<td>1.0</td>
</tr>
<tr>
<td>tasks helped develop your understanding of engineering management</td>
<td></td>
<td></td>
</tr>
<tr>
<td>If you studied principally off-campus as an undergraduate, your course materials and assessment tasks</td>
<td>3.8</td>
<td>1.1</td>
</tr>
<tr>
<td>helped develop your understanding of engineering management</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

standard deviation for each statement are given (based on a rating scale of 1 = strongly disagree, 2 = partially disagree, 3 = unsure, 4 = partially agree and 5 = strongly agree).

Respondents were asked to indicate any ways in which their undergraduate management studies could have been improved to make them more useful and relevant. Table 12 shows the responses received.

3.5.3 Discussion

3.5.3.1 Response rate
The fact that 14.8% of the originally targeted recent graduates were no longer at the most recent address recorded for them highlights the difficulty in maintaining contact with students once they leave the university.
Table 12 - Improvements to management studies suggested by respondents

| More real case studies |
| Teams, customers, budgets, contract management, tenders/specs, industry visits |
| Dealing with people, conflict resolution, effective meetings |
| Law, contract law |
| Negotiation, marketing, presentations by experts, teamwork |
| Projects, contracts and tendering, standards |
| Real HR, supervision, delegation, ethics, accepting authority |
| Communicating with all types of people |
| More hands on, more oral presentations |
| More on motivation and development |
| Project finance |
| Group work |
| Supply contracts, oral communications |
| Project management, project evaluation |
| Presentations by local managers |
| Quotation methods, maintenance management |
| Project management, scheduling, organising, more hands on, less theory |
| Skills in communication to large groups, interpersonal skills |
| More real life instead of theory |
| More in-depth units instead of a crash course |
| Team playing and open communication |
| More real world situations, rather than textbook situations |
| Body language |

3.5.3.2 Demographic information
The gender and graduating discipline proportions of the target potential respondent group were known, permitting a comparison with the actual respondent population. The proportion of female students in the target group was 16.3%, which was not significantly different from the respondent group ($\chi^2_1=0.298$, $p>0.58$). The graduating discipline proportions of the target group were Manufacturing = 54.8%, Environmental = 20.7% and Mechatronics = 24.4%, and again were not significantly different from the respondent group ($\chi^2_2=0.949$, $p>0.62$). This suggests that the
actual respondent population is a representative sample of the target potential respondent group.

Two significant demographic correlations were found to relate to study mode. The mean age of off-campus students \( (M=37.8 \text{ years}, SD=6.5) \) was significantly higher than on-campus students \( (M=27.4 \text{ years}, SD=5.6) \) \( (t_{18}=-4.834, p<0.0002) \). Off-campus students were more likely to be undertaking a three year BTech course (56.3% of BTech enrolment), whereas on-campus students were more likely to be undertaking a four year BE course (87.5% of BE enrolment) \( (\chi^2=8.75, p<0.0031) \). These results concur with prior research in the Deakin School of Engineering and Technology (Briggs, 1995) that indicates that off-campus students are principally mature aged, typically study part-time because of full-time work commitments and choose the BTech as an attainable goal to upgrade their prior trade or technical qualifications into the professional workforce; and; that on-campus students predominantly enter engineering studies directly from high school and normally aspire to the four year BE professional engineer status.

3.5.3.3 Experience in engineering practice and management roles
The experience in these areas reported by the respondents confirms that management responsibilities are part of the practice experience of recent engineering graduates in a wide range of industries and sectors.

3.5.3.4 Management skills that have been important in practice
The most frequently reported management skills (reported as important by 45% of respondents or more) include communication skills, project management, supervision and leadership, time management, decision making, teamwork, project evaluation, cost estimation, occupational health and safety and report writing. These first ten skills are all important generic professional practice skills and their high ranking matches the results obtained in the prior two surveys. This survey reveals that these skills are important even to recent graduates.

At the other end of the scale, economics and theories of management received no score at all, suggesting that they are viewed as too theoretical or too remote from the engineering practice of recent graduates. In between, there are a large number of management skills that were reported as important by less than 45% of respondents.
Some of the management skills in this middle band are possibly more specialised than generic, such as risk management, environmental management, maintenance management, legal/law, marketing and public relations, and hence reported by a smaller proportion of respondents. Other activities in the middle band may relate to higher level management issues that many recent graduates are yet to experience, such as contract management, change management, strategic management, business strategies and systems approach, and therefore again have a lower rate of reporting.

The near exponential distribution of the ranking of reported important management skills shown in Figure 5 suggests that there are a core of skills important to many graduates, then a wider range of skills relevant to particular circumstances of individual graduates.

3.5.3.5 Effectiveness of the management stream in the Deakin undergraduate engineering program

Overall, the value of the undergraduate management studies component of the courses at Deakin was rated highly, with a higher overall rating having a positive correlation with respondent age; the mean respondent age in each rating category was significantly different ($f_{3.36}=3.793, p<0.019$). Older students are likely to have had more experience of the engineering workforce and hence had an opportunity to experience the ‘management’ component of engineering work. It is the experience of the author that many students early in their undergraduate studies (particularly students entering directly from secondary school) experience some difficulty in appreciating the relevance of their management studies. The overall high rating of the management studies suggests that exposure to the real world of engineering practice quickly gives graduates an appreciation of the value of the management component of engineering. The clear message from the suggested improvements to the management studies stream is a desire for more exposure to those aspects of management practice already most highly valued. An even clearer message is the desire for more exposure to the real world practice of engineering management.

The survey questions addressing course effectiveness did not seek to differentiate between learning resources (classroom activities or study materials) and assessment, rather, the questions sought the students’ perception of the value of their studies
overall. Immediately following these questions students were invited to identify any
particular individual aspects of their undergraduate engineering management studies
that were and were not useful/relevant to them.

3.5.3.6 Other findings
The respondent group in this survey where practising members of the professional
sector of the engineering workforce, rather than academics or students. For this
reason it was considered valuable to undertake a deeper level of statistical analysis of
the results obtained to see if any additional insights into the nature and perception of
engineering management practice could be observed.

Two moderately significant differences in the reporting rate of a management skill
being important were noted between the qualification gained by the respondent. In
Australia, the occupational classification ‘engineering technologist’ refers to a three
year BTech degree qualification that fills the occupational niche in the engineering
workforce between professional engineer and engineering associate (Institution of
Engineers Australia, 1999b). Professional engineer and engineering technologist are
classified as professional occupations; engineering associate refers to graduates of
two year study programs in the vocational education sector. BTech graduates were
significantly more likely (37.5%) to report that operations management had been
important to them than compared to BE graduates (4.2%) ($\chi^2 = 7.388$, $p<0.007$). BE
graduates were somewhat more likely (66.7%) to report that project evaluation had
been important to them than compared to BTech graduates (31.3%) ($\chi^2 = 4.829$,
$p<0.028$). These results perhaps reflect that a significant proportion of BTech
students come from occupational groups focussed on operations, (engineering trades
and engineering associates), and as engineering technologist graduates, they are likely
to continue in an operations role – in Australia it would be common to find
engineering technologists working under the direction of a professional engineer.
Conversely, it is perhaps more likely that professional engineering graduates would
find themselves in the role of project planning and evaluating project feasibility
sooner than their engineering technologist counterparts.

A number of significant positive correlations were observed between the
management skills indicated as important by respondents. As the correlation
The coefficient is a descriptive statistic only, a significance test was performed on each of the observed correlations. Table 13 provides a summary of these correlations and an indication of their significance. No strong negative correlations between management skills indicated as important by respondents were observed.

**Table 13 - Correlations between management skills indicated as important by respondents**

<table>
<thead>
<tr>
<th>Respondents who indicated that this management skill was important...</th>
<th>...were also more likely to indicate that this/these management skill(s) were also important</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quality management</td>
<td>Dealing with customers</td>
<td>$\chi^2 = 8.86, p &lt; 0.0030$</td>
</tr>
<tr>
<td></td>
<td>Competition</td>
<td>$\chi^2 = 8.25, p &lt; 0.0041$</td>
</tr>
<tr>
<td>Professional ethics</td>
<td>Time management</td>
<td>$\chi^2 = 8.89, p &lt; 0.0029$</td>
</tr>
<tr>
<td>Business strategies</td>
<td>Forecasting</td>
<td>$\chi^2 = 11.8, p &lt; 0.0006$</td>
</tr>
<tr>
<td></td>
<td>Creativity</td>
<td>$\chi^2 = 11.6, p &lt; 0.0007$</td>
</tr>
<tr>
<td>Project evaluation</td>
<td>Cost estimation</td>
<td>$\chi^2 = 12.1, p &lt; 0.0005$</td>
</tr>
<tr>
<td>Lifelong learning</td>
<td>Creativity</td>
<td>$\chi^2 = 10.8, p &lt; 0.0010$</td>
</tr>
<tr>
<td>Time management</td>
<td>Work/time study</td>
<td>$\chi^2 = 10.1, p &lt; 0.0015$</td>
</tr>
<tr>
<td>Public relations</td>
<td>Negotiation</td>
<td>$\chi^2 = 10.6, p &lt; 0.0012$</td>
</tr>
<tr>
<td>Strategic management</td>
<td>Information management</td>
<td>$\chi^2 = 9.61, p &lt; 0.0020$</td>
</tr>
<tr>
<td>Cost estimation</td>
<td>Contract management</td>
<td>$\chi^2 = 8.53, p &lt; 0.0035$</td>
</tr>
<tr>
<td>Risk management</td>
<td>Report writing</td>
<td>$\chi^2 = 8.31, p &lt; 0.0040$</td>
</tr>
<tr>
<td>Design management</td>
<td>Negotiation</td>
<td>$\chi^2 = 13.1, p &lt; 0.0003$</td>
</tr>
<tr>
<td>Negotiation</td>
<td>Report writing</td>
<td>$\chi^2 = 9.81, p &lt; 0.0018$</td>
</tr>
<tr>
<td></td>
<td>Creativity</td>
<td>$\chi^2 = 9.34, p &lt; 0.0023$</td>
</tr>
<tr>
<td>Forecasting</td>
<td>Inventory management</td>
<td>$\chi^2 = 9.08, p &lt; 0.0026$</td>
</tr>
<tr>
<td>Motivation</td>
<td>Work/time study</td>
<td>$\chi^2 = 9.94, p &lt; 0.0017$</td>
</tr>
</tbody>
</table>
The association of quality management and dealing with customers is not surprising. The modern concept of quality places the customer/end-user in a position of central importance in determining and delivering quality (Deming, 1986). Likewise, the association of quality management and competition acknowledges that quality is a strategic issue in the modern business environment (Juran and Godfrey, 1999).

Two central elements of the concept of the ‘professional’ and ‘professionalism’ are adherence to a code of ethics or rules of conduct and a claim to independence or autonomy in practice. The practising technology professional often enjoys a high degree of autonomy, even as an employee engineer. The association of professional ethics and time management may represent the exposure of the recent engineering graduate to professional freedom in their work, and their realisation that the effective and productive use of their time can depend significantly on their self-motivation and personal commitment to employing their time efficiently for the achievement of organisational goals.

There is no surprise in finding a strong association between business strategies and forecasting. The strategic planning process, indeed all planning processes, involves the forecasting of future environmental conditions. Likewise, a strong association between business strategies and creativity is not unexpected. The Nobel laureate in economics Robert Solow argues that technological progress is the major factor that contributes to economic progress (Khalil, 2000). Technological progress and innovation are the result of research and development, which in turn is dependent on invention and creativity.

Project evaluation and cost estimation are natural partners; whether evaluating a project proposal, performing a project progress review or conducting a post-project audit, accurate cost estimation is important.

Organisational change is now viewed as an on-going process rather than an event, and can be viewed from many perspectives, including that of the individual(s) who facilitates organisational transformation through initiative and creativity (Kemelgor et al., 2000). Organisational change means that students now entering the workforce
may experience eight to 10 different jobs, and apart from skills in an academic discipline, a key requirement for personal success will be lifelong learning skills and attitudes (Sumberg, 2000). Whether creativity is the source of change or the skill to adapt to change, lifelong learning will be a key strategy for the renewal of skills and knowledge required to stay competitive and innovative.

Finding a link between time management and work/time study can be explained by an interest in time and its effective use as a personal and organisational resource.

Both public relations and negotiation are related under the umbrella of the marketing function, and are also closely aligned to the concept of communication and its management. The systematic linkage of these two skills/areas is illustrated by the damage that can be caused to a corporate negotiating position by poorly conceived public communications (Ertel, 1999).

The emerging view of organisational knowledge and information technology as strategic enablers for business performance supports the observed association between strategic management and information management. The strategic value of corporate information and knowledge comes not merely from putting information in databases, but from leveraging this information into the organisation’s operations – from active information management (Cross and Baird, 2000).

As with project evaluation, cost estimation is a natural partner of contract management.

The observed link between the reporting of risk management and report writing may arise from the central role that documentation plays in risk management systems. The process of risk management includes risk identification, risk assessment, risk response and risk documentation (Basu, 1998). Processes for risk management must be documented, as must occurrences of reportable incidents identified under the risk management system.
Statistically significant co-reporting of design management and negotiation may result from the human resource management issues that arise in the management of design professionals. Design professionals, such as engineers, value autonomy and recognition of their technical expertise. The ‘situational leadership’ approach suggests that improved motivation can be derived from carefully controlling the assignment of work. Less skilled staff may require close direction, whereas experienced staff may work better in situations where they are given the required goals, but also given significant freedom regarding the means by which these goals are achieved (Humphrey, 1997). Dealing with experienced professionals in this manner may require negotiation regarding delivery dates, acceptance criteria, etc. Additionally, those with design management responsibility may find themselves negotiating those characteristics of their projects for which agreement would normally have to be reached, including scope of work, budget and schedule.

Respondents indicated an association between negotiation and report writing, and negotiation and creativity. The literature strongly suggests that creativity is the key to successful negotiation that goes beyond win-lose, compromise, avoidance or accommodating strategies, and seeks a ‘win-win’ goal (Schwartz, 1997). Likewise, a key factor in ensuring that the outcomes from successful negotiation are fully realised is clear documentation and reporting, once a full understanding has been reached by the negotiating parties (Fowler, 1990).

A link in the reporting of forecasting and inventory management is supported by the modern goal of supply chain management, which looks beyond simple control of stock levels, to the full integration of logistics as a loop from customer service levels to forecasting (Lawrence, 1999).

An association between motivation and work/time study was observed. Though often viewed as somewhat ‘Taylorian’, work measurement and time study still play an important role in the quantification of time and cost, and in providing goals and incentives for some employees (Lawrence, 1997).
This survey of recent Deakin graduates suggests that those management skills most highly valued by graduates were generic professional practice skills, and that more exposure to opportunities to develop these skills in undergraduate studies would be beneficial. A large range of other management skills were valued as important, depending on the discipline or employment sector of the graduate. Only highly abstract management skills were not rated as important by any respondent. While the overall survey rating of the value of undergraduate management studies was high, engineering undergraduates tend to take some time to appreciate the value of their management studies (Young, 1997). One possible solution to this issue is suggested from the survey results relating to how the management studies stream could be improved, that is, recent graduates suggest the inclusion in the course of more ‘real world’ examples of engineering management, including case studies, hands-on activities, industry visits, more in-depth coverage of topics and presentations from practising professionals.

3.6 Comparison of results

The following examines the three surveys conducted as part of this project to check for consistency of results between the respondent groups, and also to check for consistency with similar survey exercises documented in the literature.

3.6.1 Comparison of survey results

The data from the three surveys is principally categorical/descriptive and not numerical/quantitative, and each survey produced a similar but unique set of data that are not directly comparable using quantitative statistics. However, the three surveys conducted as part of this project exhibit a high degree of consistency of results, especially given that although the three respondent groups are associated with engineering, they come from very different perspectives and experiences. The surveys suggest that the ranking of engineering management skills viewed as important falls into three categories:

1. generic professional practice skills, for example -
   • written and oral communication skills
   • project management
   • supervision and leadership
   • teamwork;
2. generic management skills and specialised technical discipline management skills, for example -
   - human resource management
   - business strategies
   - organisational behaviour
   - quality management
   - risk management
   - maintenance management; and
3. theoretical skills and skills related to other professional disciplines, for example -
   - theories of management
   - economics
   - accounting.

This result provides a degree of confirmation based on internal consistency, as well as confirming the author’s intuitive notion of the likely outcome. The issue of what undergraduate students ‘should’ study in their courses is addressed in Chapter 7.

3.6.2 Comparison with the literature
Many surveys of students, practising engineers and employers of engineers are noted in the literature, but many do not provide the level of detail in their results necessary for a comparison with the results obtained in this project.

Waddell and Rosan (1995) identify the deficiencies in management education reported in the Karpin Report (Karpin, 1995), and sought to identify what management skills were required by engineers in Victorian manufacturing organisations. 100 companies were surveyed, but the response rate was not indicated. The survey employed a skills inventory and Likert-style response system similar to those used in the project. However the skills inventory was relatively small and was structured around the general management functions of planning, organising, controlling and leading, potentially yielding a constrained range of responses. The management skills receiving the highest ranking in their survey were:

“
- Developing plans to coordinate activities;
- Negotiating with peer level;
- Negotiating with superior levels;
- Directing others; and
- Negotiating with subordinate levels” (Waddell and Rosan, 1995, 137).

These are all generic professional skills or generic management skills, and their high ranking agrees with the ranking framework proposed in this project.

Williams (1996) investigated the associated area of management competencies required by science graduates, and surveyed 288 science graduates and 384 employers of science graduates in the United Kingdom to ascertain their perceived importance of an inventory of 14 management competencies, based on responses to a five point Likert-style rating scheme. Figure 6 shows the summary responses of the employers of science graduates and Figure 7 shows the summary responses of the science graduates.

The rankings of management competencies reported by science graduates and their employers are ordered only slightly differently from each other, and the proposed ranking framework of generic professional skills first, followed by general management skills and technical discipline specific management skills, followed by other professional discipline skills and theoretical skills agrees with the observed results.

Owen (1997) reported on the outcomes of a series of six industry workshops sponsored by the American Society of Automotive Engineers to identify what US manufacturing managers and executives believe that engineering graduates need to know. While the workshops considered all knowledge and skills areas that graduates require, the ranked list provides an insight into not only the relative importance of particular management skills, but also the absolute importance of management skills compared to technical skills. The list in ranked order of importance was:
Figure 6 - Importance of management competencies as ranked by employers of UK science graduates.

Source: (Williams, 1996, 312).

“

1. communication skills,
2. teamwork,
3. personal attributes,
4. manufacturing principles,
5. product and process reliability,
6. project management,
7. manufacturing processes,
8. business skills,
9. quality systems,
10. change management,
11. statistics and probability,
Figure 7 - Importance of management competencies as ranked by UK science graduates.

Source: (Williams, 1996, 312).

12. ergonomics,
13. materials science and applications, and

Management skills and knowledge are represented strongly, and dominate the highest list rankings. The executives saw the top three items on the list as clearly the most important for graduates. Once again, generic professional skills rank highest, followed by a mixture of technical and general management skills.

Batley (1998) reported on the importance of management to professional engineers in New Zealand, and their need for training and education to develop their management skills. Batley surveyed more than 120 New Zealand engineers using a management
skills inventory and a reverse Likert-style ranking scheme. Figure 8 shows the results obtained - note that in this case, the lower the ranking score, the more important the management skill was considered by respondents.

![Management Skills Chart]

**Figure 8 - Importance of management skills ranked by professional engineers in New Zealand**

Source: (Batley, 1998, 311).

The results again show the trend of generic professional skills being reported as the most important. Interestingly, supporting the proposed framework model that
technical discipline specific management skills and management skills related to other professional areas will be reported as less important, Batley notes:

“The management subjects at the lower end of the ranked list indicate less desire for management training in these areas. This may be because engineers believe:

- skills and techniques can be provided more easily by a specialist, e.g. business law, information systems;
- subject is not appropriate to their particular work, e.g. production and operations management, quantitative methods, marketing...” (Batley, 1998, 310).

Bellinger (1998) presented a survey of 681 American electronic engineers, including those with technical/design roles and those with management roles, that sought to identify those management/business skills perceived as most important by the respondents. The survey gives the percentage of respondents who indicated that a particular management skill from an inventory was important. Figure 9 shows the responses from engineering managers and Figure 10 shows the responses from design engineers.

As might be expected, those in engineering management roles have more frequently reported all business skills than those in engineering design roles. The order of ranking of the management skills differs somewhat between the two groups, but within the limited inventory employed in the survey, the proposed framework is generally supported again, with generic professional skills ranking generally higher than more specialised management skills.

Bellinger (1999) presented a follow-up survey to that above, covering 503 American electronic engineers, including those with technical/design roles and those with management roles, that sought to identify those management/business skills perceived as most important by the respondents. The survey gives the percentage of respondents who indicated that a particular management skill from an inventory was important. Figure 11 shows the responses from engineering managers and Figure 12 shows the responses from design engineers.
Figure 9 - Importance of business skills as ranked by US electronics engineering managers

Source: (Bellinger, 1998, 125).

Figure 10 - Importance of business skills as ranked by US electronics design engineers

Source: (Bellinger, 1998, 125).
Figure 11 - Importance of business skills as ranked by US electronics engineering managers

Source: (Bellinger, 1999, 95).

Figure 12 - Importance of business skills as ranked by US electronics design engineers

Source: (Bellinger, 1999, 95).
It is apparent that only minor changes in business skill ranking have occurred between the two survey periods, both within the two respondent groups and in the relative rankings between the two respondent groups.

Mallick and Chaudhury (2000) investigated the related area of the importance of knowledge and skills required for the management of technology, focussing on the requirements for MBA courses. Their investigation is relevant, as the single largest first degree discipline of MBA students is an engineering qualification (Gault, 1999).

Their investigation is also relevant, as they sought to compare the responses of academics involved in the delivery of United States MBA programs with those of practising managers of technology. Their survey was sent to 307 academics and 300 executives in technology firms. Respondents were asked to rate the importance of a management skills inventory using a five point Likert-style rating scheme. Figure 13 shows the responses from academic respondents and Figure 14 shows the responses from practising managers of technology. Once again, there are some differences in the individual rankings of management skills by the two respondent groups, but the general order of rank of the management skills conforms to the proposed framework.

Overall, the international literature describing surveys to establish the ranking of the importance of management skills in the engineering and related science/technology fields provides support for the proposed framework developed from the project surveys. The implications of the framework and its ranking of management skills classifications will be addressed in Chapter 7.

As noted previously, in the context of undergraduate education, the term ‘engineering management’ has historically included a range of material that could be classified as non-technical and/or generic professional skills - this can be readily appreciated by examining the topic areas presented in Table 2. In many engineering programs the engineering management units attract much of the non-technical and non-discipline-specific course content. This approach is likely to become more common, with the new IEAust course accreditation guidelines requiring only four categories of course
Figure 13 - Importance of technology management skills ranked by academics in US MBA programs

Source: (Mallick and Chaudhury, 2000, 163-164).

content; engineering science, engineering design, an engineering discipline specialisation and:

“...integrated exposure to professional engineering practice (including management and professional ethics). This element should be about 10% of total program content;” (Institution of Engineers Australia, 1999a, 6).
Figure 14 - Importance of technology management skills ranked by executives responsible for technology management in industry in the US

Source: (Mallick and Chaudhury, 2000, 163-164).

The surveys in this project and the literature discussed above suggest that there is a growing recognition that these generic professional practice skills are in fact the most important elements of management studies, and some would even suggest, the most important element of all engineering studies. Recognition of the importance of generic professional practice skills leads to a need to understand the nature of these
skills and effective methods for their delivery and assessment. This is the focus of the following chapter.
4 - Student responses to activities designed to develop generic professional practice skills

4.1 Introduction
One key idea established thus far is the importance of generic professional practice skills for the practising engineer. This chapter examines the importance of generic professional practice skills in the context of engineering education, and the responses of undergraduate students to study activities designed to develop and assess these skills.

4.2 Generic professional practice skills in engineering education
As identified previously, many reviews of engineering and engineering education in Australia over the last two decades have documented a preponderance of technical and discipline-specific course content over non-technical and professional practice skills (Lloyd et al., 1979) (Williams, 1988) (Bates et al., 1992) and:

“Academic staff utilise the existence of senior elective subjects to interact with undergraduates and possibly enthuse and attract research students. These latest developments generally add to the already overcrowded technical content of the undergraduate programs and act directly against the often stated desired outcome for a well-rounded graduate.” (Johnson, 1996b, 82).

Yet these same reports identify that it is exactly these non-subject-based skills that both students and employers of graduates identify as generally lacking in current engineering undergraduate studies. The ‘Interface with Industry’ task force of the Johnson review of Australian engineering education sought to encapsulate industry’s desires for engineers as:

“...
  • competent communicators in speech, writing and other media, both with other engineers and with people of non-technical backgrounds;
• people with a clear understanding of the business, economic, environmental and sociological context in which engineering decisions are made and projects delivered;
• innovators with a balance between the creative and analytical aspects of engineering, and with an ability to work as part of a team on practical problems;
• members of a profession which reflects a broad range of social and cultural backgrounds.” (Johnson, 1996b, 50).

In this regard, these recent reviews of Australian engineering education mirror the findings and recommendations of similar review exercises conducted internationally (Accreditation Board for Engineering and Technology Inc., 1997) (The Canadian Academy of Engineering, 1993) (Working group on lifelong learning and continuing education in engineering, 1998).

Other recent sources identify the increasing importance of generic professional practice skills for undergraduate students (Riley and Pickering, 1995) (Adamski, 1999). Smith (1992) suggests:

“The graduate engineer today cannot totally rely on analytic abilities alone. To launch a successful career in engineering effectively, individuals must develop a strong character infrastructure...The three critical elements of professionalism are communication, teamwork, and self-management skills.” (Smith, 1992, 258).

Employers value the possession of these skills (Aulich, 1990). A National Board of Employment, Education and Training report (1992) included an Australian survey of 100 employers of new graduates in which the most important selection criteria applied to new graduates were sought. The results are given in Table 14.

Inclusion of these elements in undergraduate curricula is conducive to the development of lifelong learning habits in students, which in turn are likely to assist graduates in their long-term professional careers (Hargreaves, 1996) (Hecker, 1997). Candy et al. (1994) suggest:
Table 14 - Selection criteria applied to new graduates

<table>
<thead>
<tr>
<th>Selection Criteria</th>
<th>% of Respondents</th>
</tr>
</thead>
<tbody>
<tr>
<td>Academic results</td>
<td>90</td>
</tr>
<tr>
<td>Oral communication skills</td>
<td>74</td>
</tr>
<tr>
<td>Ability to work in teams</td>
<td>73</td>
</tr>
<tr>
<td>Interpersonal skills</td>
<td>71</td>
</tr>
<tr>
<td>Initiative</td>
<td>69</td>
</tr>
<tr>
<td>Conceptual &amp; analytical ability</td>
<td>66</td>
</tr>
<tr>
<td>Flexibility/adaptability</td>
<td>61</td>
</tr>
<tr>
<td>Enthusiasm</td>
<td>61</td>
</tr>
<tr>
<td>Written communication skills</td>
<td>58</td>
</tr>
<tr>
<td>Willingness to learn</td>
<td>54</td>
</tr>
</tbody>
</table>


“...teaching methods that encourage graduates to become lifelong learners have the following characteristics: (1) they make use of peer-assisted and self-directed learning; (2) they include experiential and real-world learning; (3) they make use of resource-based and problem-based teaching; (4) they encourage the development of reflective practice and critical self-awareness; and (5) as appropriate, they make use of open learning and alternative delivery mechanisms” (Candy et al., 1994, xii).

The list of desirable generic skills identified in the literature includes, but is not limited to, the following:

- self-direction;
- critical self-awareness;
- an understanding of societal context;
- resource-based learning;
- experiential learning;
- written and oral communication;
• computer literacy;
• leadership and supervision;
• research and analysis;
• managing and organising; and
• teamwork.

Many of these skills are closely related to the concept of student-centred learning, and to the development of deep rather than shallow learning (Hargreaves, 1996) (Fraser and Deane, 1997). The recent engineering education literature shows many examples of attempts to incorporate these generic skills into undergraduate curricula, indicating educators’ growing awareness of the value of these skills.

Closely related to the idea of curricula designed to develop generic practice skills and student-centred learning is the application of appropriate assessment activities. Traditional assessment activities are often designed to test the ability of the student to recall learned information, or to handle closed forms of academic problems with which they are familiar. These types of assessment reward a surface approach rather than a deep approach to learning. Open-ended research/problem-based assessment activities that involve students in the search for and analysis of their own information can assist in the development of generic skills that transcend discipline subject knowledge:

“Instructional objectives may be either subject matter or developmental. Subject matter objectives specify disciplinary knowledge...Developmental objectives express how people think or feel, and often describe skills and attitudes...In science courses, developmental objectives include critical thinking, an appreciation of the value of the scientific way of knowing, and the ability to continually renew oneself in science and technology...four instructional techniques used to deliver specific developmental objectives...are:

• The mini-research project
• The scenario-based research project
• The short essay-examination question
• And, the issues-directed research project.” (Adams, 1993, 100-101).

Given that ‘management studies’ units in engineering programs are often given the main task of developing generic professional skills (this is certainly currently the case at Deakin), and that prior project research highlighted the perceived importance of these generic professional skills by the stakeholders in undergraduate engineering management education, it was considered important to investigate how assessment tasks might be designed to develop and exercise these skills and to evaluate the perceived effectiveness of these assessment tasks. This chapter presents a case study from the professional practice of the author where an existing study unit was adapted to incorporate a number of new assessment tasks aimed at the development of generic professional practice skills.

The unit that formed the setting for the assessment activities described in this chapter was a final-year management studies unit at Deakin University, SEB421 Strategic Issues in Engineering. This unit consists of three modules:

• Technological forecasting and assessment;
• Policy design in engineering organisations; and
• Issues in productivity improvement.

The ‘technological forecasting and assessment’ module discusses methods for forecasting, creativity, factors in technological innovations and the impact of technological changes on business and society. The topics in the ‘policy design in engineering organisations’ module are policy concepts, approach to policy design, policy interactions and examples in policy design. The ‘issues in productivity improvement’ module focuses on labour productivity, productivity improvement techniques, benchmarking, the changing nature of work practices and management productivity.

In this unit, existing assessment methods were supplemented with a number of new assessment methods intended to exercise and develop a range of generic professional practice skills. The total inventory of assessment activities was:

• group / team work;
• case study analysis;
• report writing;
• oral presentation;
• group self-assessment / peer assessment;
• industrial visits / interviews; and
• reflective journals.

It was not considered necessary to change the existing subject content, and a conventional end-of-semester, closed-book exam was also used, accounting for 50% of the total unit grade.

4.3 Methodology

Since a number of new assessment approaches were being introduced concurrently, and that the students’ prior exposure to these assessment techniques was not known, the students were surveyed at the beginning of the semester in July 1997. A copy of the questionnaire employed is included in Appendix D - Questionnaire used at start of semester for evaluation of assessment methods. The survey measured the level of prior experience with the assessment activities to be used, so as to quantify the students’ initial perceptions of them. To complement this initial data the measurement of the students’ perceptions was repeated at the end of the semester in October 1997, following their exposure to them in this context. A copy of the questionnaire employed is included in Appendix E - Questionnaire used at end of semester for evaluation of assessment methods. At the same time, descriptive comments were invited regarding the benefits and limitations of each assessment approach. The team / group elements were made optional for off-campus students, so the survey was limited to on-campus students. As noted for the surveys previously presented:

• as required by university ethics procedures, all of the surveys conducted for the project were anonymous and voluntary;
• to encourage good response rates under these conditions, the questionnaires were kept as simple and straightforward as possible;
• hence, factor analysis, internal reliability testing and piloting were not performed; and
• a range of data are presented and analysed in the surveys, some of them quantitave and some of them descriptive, hence both descriptive and parametric statistical analyses are used as appropriate.

4.4 Results

4.4.1 Demographic information
The on-campus class size at the beginning of the semester was 18; the end-of-semester survey size was 15; this reduction arose because some students either withdrew from the unit after commencement, or switched to off-campus mode to better suit their personal circumstances. In both cases, a 100 percent response rate was obtained from the on-campus classes. The mean age of the students was 22.4 years. Figure 15 presents the students’ prior experience with the assessment activities.

![Bar chart showing assessment tasks]

**Figure 15 - Students’ prior experience with assessment tasks**

Students were asked to indicate their perception of the value of each of the assessment activities via a Likert rating scale (the exact questions asked for each assessment approach are described in the following sections). A rating of 1 indicates
strong disagreement with the question / statement presented, 2 indicates moderate disagreement, 3 indicates indecision, 4 indicates moderate agreement and a rating of 5 indicates strong agreement. A mean student rating for each assessment activity was obtained by averaging the numerical sum of the individual student ratings. As indicated, this exercise was undertaken at the beginning of the semester and repeated at the end of the semester to establish both initial and final perceptions. Figure 16 summarises the students’ start-of-semester and end-of-semester perceptions, indicating the mean student ratings and the standard deviation of those responses.

![Graph showing change in students' rating of assessment tasks](image)

**Figure 16 - Change in students’ rating of assessment tasks (comparison of mean ratings)**

### 4.4.2 Group work

While no formal grade was attached to participation in group work, students were required to work in groups for all assessment activities except the reflective journal. The students were briefed about the potential benefits and drawbacks of group / team work and strategies for dealing with group organisation and decision making were suggested. The students organised themselves into groups of three and were responsible for organising all of the group’s tasks among themselves. Group work had been experienced previously by 88.9% of students. Students were asked to rate
their perception of group work by responding to the question, “Do you think that working in groups is better than working individually?”, using the Likert rating scale described above.

At the start of the semester the mean student response was 3.44 and the standard deviation of the rating was 0.90, indicating qualified support for the value of group work tasks. At the end of the semester the mean student response was 4.00 and the standard deviation was 0.63, indicating a significant change ($t = -2.02, p = 0.026$). The experience of undertaking several group work tasks over the course of the semester seems to have improved the perception of group work to a level of moderate support, and increased the agreement in this perception. At the completion of the semester students were also requested to provide descriptive feedback on this assessment activity via the question, “What do you perceive the positive and negative aspects of group work to be?” Typical responses received were:

Positive:
- ‘provided extra motivation’;
- ‘more discussion of the problem and more ideas’;
- ‘shares the work around’;
- ‘it was fun’;
- ‘there was a synergy and teamwork’; and
- ‘a chance to practice teamwork’.

Negative:
- ‘requires good organisation and communication abilities’;
- ‘hard to find times to suit everyone’;
- ‘some people don’t complete their tasks on time’;
- ‘not everyone pulled their weight’;
- ‘some work was duplicated’; and
- ‘some members didn’t input, they sat back and took the credit with the group’.
4.4.3 Case studies
For two assignments, the student groups were asked to locate recently published case studies relating to the course material being studied at that time. Examples of undertaking a review of the literature, appropriate sources of information and the expected ‘quality’ of the case studies were provided to the students. They had to answer a series of questions regarding how the organisations documented in their case studies responded to particular issues. A third case study exercise involving the student groups visiting an engineering organisation is described below. Additionally, each case study exercise involved preparing a written report and giving a class oral presentation; these are also described in more detail below.

Case study exercises had been experienced previously by 77.8% of students. Students were asked to respond to the question, “Do you think that case study exercises are a valuable learning tool?” The initial mean student response was 4.00 and the standard deviation was 1.00, indicating moderate support for case study exercises. At the end of the semester the mean student response was 4.27 and the standard deviation was 0.77. While this is not a significant change ($p > 0.2$), it does indicate significant support for case study exercises and good agreement in this perception. At the end of the semester students were asked, “What do you perceive the positive and negative aspects of case study exercises to be?” Typical responses received were:

Positive:
- ‘opportunity to review how others write reports’;
- ‘helps relate the class theory to real life practice’;
- ‘makes the study notes easier to comprehend’;
- ‘allows us to utilise the new skills and knowledge learned in class’; and
- ‘will help me avoid some of the mistakes made by others’.

Negative:
- ‘difficult to locate relevant material’;
- ‘extra reading to do’; and
- ‘more difficult than course work alone’.
4.4.4 Report writing

For the three case study exercises, the student groups were asked to prepare a written report detailing their findings. These reports were required to be professionally presented, including referencing, diagrams where appropriate and good spelling and grammar. A checklist of requirements and good practice for written reports was provided to the students. Across the semester, the three reports totalled approximately 6000 words per group. The companion exercise to each written report was an oral presentation, described further below.

Preparing written reports had been experienced previously by 100% of students. Students were asked to respond to the question, “Do you think that preparing written reports is a valuable exercise?” The initial mean student response was 4.28 and the standard deviation was 0.99, indicating good support for the value of written reports. At the end of the semester the mean student response was 4.07 and the standard deviation was 0.57. This is not a significant change ($p > 0.2$) and indicates significant support for report writing and good agreement in this perception. At the end of the semester students were asked, “What do you perceive the positive and negative aspects of report writing to be?” Typical responses received were:

Positive:
- ‘improves written communication ability, industry employs articulate engineers’;
- ‘the preparation required reinforces the theory’;
- ‘good experience – even though most engineers don’t like documentation, it is required by many aspects of engineering’; and
- ‘being able to express collected information in a logical argument or finding’.

Negative:
- ‘an ugly, difficult process (personal opinion)’;
- ‘writing the report’;
- ‘report writing skills are already well practiced’; and
- ‘we always write reports – it gets boring’.
4.4.5 Oral presentation
For the three case study exercises, the student groups were asked to prepare and deliver oral presentations to the class. These presentations were to be professionally delivered, and an array of visual display equipment was made available to the students, including overhead projection, video playback and computer projection. A checklist of requirements and good practice for oral presentation was provided to the students. Across the semester, the three presentations totalled approximately 40 minutes per group.

Delivering oral presentations had been experienced previously by 94.4% of students. Students were asked to respond to the question, “Do you think that giving oral presentations to groups is a valuable exercise?” The initial mean student response was 4.14 and the standard deviation was 0.94, indicating good support for the value of oral presentations. At the end of the semester the mean student response was 4.53 and the standard deviation was 0.72; a moderately significant increase ($t = -1.32, p = 0.098$) indicating very significant support for oral presentations and good agreement in this perception. At the end of the semester students were asked, “What do you perceive the positive and negative aspects of oral presentations to be?” Typical responses received were:

Positive:
- ‘you really have to know your stuff’;
- ‘requires self-confidence, a clear mind and has to be entertaining – all good challenges to take on’;
- ‘has been extremely positive’;
- ‘an extremely valuable skill for industry and an underdeveloped skill at Uni’;
- ‘the more practice the better’;
- ‘you learn cooperation and respect’; and
- ‘personally satisfying when completed’.

Negative:
- ‘other presentations can be boring’;
- ‘I don’t like it much’;
• ‘it would be fun too if I wasn’t so nervous’; and
• ‘not an enjoyable process (personal opinion)’.

4.4.6 Group self-assessment
In prior assessment activities involving group work and, indeed, in the case reported above, some students had cause to comment that not all group members contributed their share of the group’s work. In an attempt to encourage the groups to resolve this issue themselves, or at least provide a mechanism to cater for circumstances where they couldn’t, each group assignment submission had to be accompanied by a group work declaration form. On this form the group had to indicate what percentage of the overall effort was contributed by each group member and all members had to sign the form. For example, in a three-member team where the contribution was agreed by the group to be equal, each member would indicate 33.3% on the form. Overall grades were assigned by the academic assessor and, if all contributions were equal, each group member received the same mark. If the contributions were not equal, the mark for those contributing less would be reduced proportionately.

Group self-assessment had been experienced previously by 50.0% of students. Students were asked to respond to the question, “Do you think that self-assessment, where you contribute to the mark you get for a piece of work, is better than assessment solely by the teacher?” The initial mean student response was 3.61 and the standard deviation was 1.16, indicating limited support for self-assessment. At the end of the semester the mean student response was 3.53 and the standard deviation was basically unchanged at 1.15. There was no significant change ($p > 0.4$) and no strong agreement in the perceived value of self-assessment. At the end of the semester students were asked, “What do you perceive the positive and negative aspects of self-assessment to be?” Typical responses received were:

Positive:
• ‘our group worked well, but it was good to have the flexibility to change marks if needed’;
• ‘it lets us decide the amount we actually did’;
• ‘group assessment was good, but individual assessment is too subjective’; and
• ‘it forces group discussion about individual input and helps highlight inequities’.

Negative:
• ‘don’t think it makes much difference, everyone judges themself anyway’;
• ‘it is unlikely that you would give a team member a lower mark than yourself, unless they did nothing’;
• ‘if you work with friends, you feel reluctant to cut others’ marks’; and
• ‘discussions about individual performance may be uncomfortable’.

4.4.7 Industrial interviews
Each student group was required, as a group, to interview a senior manager of a local engineering organisation to discuss that organisation’s approaches to the issues studied in class. The goal was to expose the students, first hand, to real engineering management practices and to allow them to compare this to the theories discussed in class. Since surveys, questionnaires and interviews fall under the university’s classification of human research and are therefore subject to the requirements of ethics approval; significant preparation was required to brief the students on acceptable interview protocols. A list of suggested interview topics was provided to the students and an introductory letter was provided that explained the purpose of the exercise to the interviewee, but, other than that, the students had to identify, contact, secure the participation of, and interview a manager of their own choice. The resulting case study was presented in a written report and a class oral presentation, as described previously.

Industrial interviews had been experienced previously by 44.4% of students. Students were asked to respond to the question, “Do you think that visiting and interviewing a member of an engineering company would be a valuable exercise?” The initial mean student response was 4.44 and the standard deviation was 0.76, indicating strong support for industrial interviews. At the end of the semester the mean student response was 4.33 and the standard deviation was 1.14. This does not represent a significant change ($p > 0.35$), but does show a greater spread of opinion regarding support for industrial interviews. At the end of the semester students were
asked, “What do you perceive the positive and negative aspects of industrial interviews to be?” Typical responses received were:

Positive:
- ‘extremely valuable as we obtained an insight into how various companies operate’;
- ‘it was valuable to practice communication skills with people involved in management’;
- ‘an insight into the way businesses operate in the real world’;
- ‘easier to research and remembered much better in comparison to reading a book’; and
- ‘very much a learning experience’.

Negative:
- ‘the time required – but the positives outweigh the negatives’;
- ‘time constraints’; and
- ‘no negative aspects’.

4.4.8 Reflective journal
Each student was required to individually keep a reflective journal. The purpose and value of critical reflection as one of the main avenues for the self-development and consolidation of knowledge based on the experience of the practising professional were explained to the students. At the completion of the weekly class, students were asked to respond in writing in their journal to the following two questions, “What did I learn today?” and “How will this be of use to me in the future?” As long as the response was thoughtful and considered, students received one percent of their final grade for each week they completed a journal entry, up to a maximum of 10%.

Reflective journals had been previously kept by 38.9% of students. Students were asked to respond to the question, “Do you think that keeping a journal of your thoughts and ideas about the material studied in class would be a valuable exercise?” The initial mean student response was 3.83 and the standard deviation was 0.83, indicating moderate support for a reflective journal. At the end of the semester the
mean student response was 3.33 and the standard was 1.07; a moderately significant
decrease \( t = 1.42, \ p = 0.083 \). At the end of the semester students were asked,
“What do you perceive the positive and negative aspects of reflective journals to be?”
Typical responses received were:

Positive:
• ‘introspection’;
• ‘easy marks – encouraged me to come to lectures’;
• ‘by putting what we learnt in writing it makes you think about it and we may
  remember it for longer’; and
• ‘forces review and self-assessment of things learnt’.

Negative:
• ‘a little repetitive’;
• ‘it’s OK, but I found myself trying to reproduce notes, rather than putting down
  thoughts and ideas’; and
• ‘value of journal as an educational tool is questionable’.

4.5 Discussion

4.5.1 Demographic information
Referring to Figure 15, more than 75% of students reported prior experience with
group work, case study analysis, report writing and oral presentation. Although these
are compulsory tasks in units prerequisite to SEB421, not all students had given an
oral presentation or worked in a group. Apparently some of the students enrolled in
SEB421 had transferred into the Deakin University course with exemptions in the
prerequisite units based on prior studies undertaken elsewhere. The potential
problems of students who do not complete prerequisite learning activities because
they enter courses with unit exemptions based on recognition of prior learning and
experience are discussed further in Chapter 5. The responses for prior experience
with the remaining assessment techniques were 50% or less.
4.5.2 Group work

The student comments clearly identified the group/team work positives of workload sharing, an extra source of ideas, the ‘motivation’ that group norms can provide for students who would otherwise perform at a lower level and the ‘synergy’ that can arise in a high performing group. The student comments also clearly identified the principal downsides of group work, that is, the extra organisational overhead of meeting and collaborating and the perception of unequal work contribution by group members.

Research suggests that groups should include between three and six members depending on the nature of the task to be completed (Johnson and Johnson, 1994), though, for students, problems with meeting times and poor participation by one or more group members increase with group size. The group size for the unit was nominally set at three and the groups were encouraged to remain together throughout the semester, unless there were exceptional circumstances (for example, more than one student out of a group of three withdrawing from the unit).

Group work offers perceived benefits to students and is more representative of the true engineering work environment. This benefit comes at the cost of requiring students to be more organised and to exercise communications and group dynamics skills. Rosser (1998) notes another possible source of student resistance to group work that may not be overtly articulated by students themselves:

“...until recently most students have been taught content mainly by lectures in science, engineering, and mathematics courses, they do not expect to actively participate, and they may oppose groups because they require more work.” (Rosser, 1998, 5).

Group work has the administrative benefit for academic staff of reducing the number of assignment submissions to be graded. Care must be taken to ensure that group work does not become an excuse for lack of individual learning and performance. The significant component of group work employed here was counterbalanced with a conventional end-of-semester examination worth 50% of the unit grade and a
mandatory requirement to pass the examination; an apparently good performance in the group work activities would not by itself be sufficient for success. Additionally, it was required that all group members contribute to all group activities. For activities such as oral presentations, the contribution of each group member was obvious. For each assessable group assignment the group was required to submit a signed group work declaration documenting their relative contributions, as peer-assessed by the group. This aspect is discussed further below.

Other factors reported as important in group work in an educational setting include group member selection (including difficulty gaining group membership and/or difficulty with group acceptance) and group member ability (Slavin, 1990). In this case, students were permitted to self select their groups and no explicit comments were received regarding issues of group acceptance or team member ability. This may arise from the fact that students in this unit were (due to prerequisite requirements) in at least their third year of study, so it could be assumed they would be in possession of some basic level of social maturity and educational ability. Additionally, many of the students in the same unit may also have formed friendships by that stage of their studies.

4.5.3 Case studies
Students identified ‘learning’ from documented case studies, not just facts and information from the details presented in the case theme, but also from the format and style of the case presentation. A key benefit noted by students was that case studies helped relate class theory to the real world, providing a context in which their new knowledge could be better understood. Significantly, a number of students reported that they could see no negative aspects to case study exercises. The primary negative aspect noted regarding case studies was the additional work required to locate and read the case studies.

Raju and Sankar (1999) describe the value of case studies in engineering education to enhance not only domain-specific technical knowledge, but also to provide the breadth of knowledge and skills fundamental to the practice of the profession. They argue for the:
“...need to develop case studies that describe technical issues along with financial, marketing and management issues.” (Raju and Sankar, 1999, 501).

They also report on a student evaluation following the implementation of case studies in their teaching, and the feedback obtained mirrors that reported here. They suggest that students found that the case studies helped them reflect on material they had learned across their studies and begin to appreciate where they might use this knowledge in practice. They also note student comments relating to the extra work required to review the case study and locate additional information needed.

One section of the class theory in SEB421 was presented almost completely as a series of case studies and student feedback indicates that this approach was not well received. A number of students commented that this approach left them confused and unclear about what the main point of the course material was. They said case studies were inappropriate as the principal learning tool, but when used as an adjunct to conventionally presented theory, they provided a valuable supplement and helped place the classroom theory in a real world context.

The development of ‘custom made’ case studies can be expensive and time consuming, and the desire to make the case study as complete and self-contained as possible may lead to simplifications so that students can ‘get the right answer’. Raju and Sankar (1999) argue against the ‘clear cut solution’, they suggest that the cross-disciplinary approach to case studies more closely reflects reality. Case studies were introduced into the unit SEB421 in a manner that was open ended, but without extensive investment in the development of self-contained learning resources. The approach taken was to allow students to locate their own documented case study from the literature. Consistency of learning objectives was achieved by providing a theme/topic for the case study and a framework of issues/questions to be used in analysing the case study.
4.5.4 Report writing
All students had encountered report writing previously, so it is perhaps not surprising that something so familiar received a high initial rating. Students recognised that written communication would be an important skill in their professional practice, and even though report writing may not be their favourite task, they could see the value in completing report writing exercises. Students also reported that writing about ideas helped to reinforce and organise their understanding about those ideas. These and other learning goals of incorporating writing tasks into engineering education are noted by Wheeler and McDonald (2000):

“Writing allows students to develop and use critical thinking skills. It enhances active learning and addresses the needs of students with different learning styles. It is a uniquely powerful tool for assessing student understanding...Similarities between the writing and design processes can be used to highlight the fact that there is often no single “correct” solution in either and that feedback and revision are often crucial to both. Finally, the status of our profession is enhanced when engineering graduates can communicate effectively.” (Wheeler and McDonald, 2000, 481).

By the end of the semester the high rating of report writing had fallen slightly; the reasons for this are perhaps found in the negative comments quoted above. Not all students enjoyed the writing process, though they recognised the importance of written communication in professional practice. Somewhat surprisingly, the students noted the amount of report writing they do across their studies as a negative comment, suggesting that there is room in the course for alternative assessment methodologies.

4.5.5 Oral presentation
Oral presentation received the highest rating of all the assessment activities employed, and this score was obtained at the end of the semester after three presentations had been made. In fact, many students reported no negative aspect to oral presentation. Positive responses received indicated that oral presentation was challenging but rewarding. Negative responses received highlight that most students were not naturally comfortable with oral presentation.
Oral presentation is an important skill for technology professionals. Kulacki and Vlachos (1995) suggest that the ‘current or past engineer’ is a “technical expert who solves a problem and writes a report”, and the ‘emerging engineer’ “manages people or a process and must communicate results to others in writing, graphically or orally.” (Kulacki and Vlachos, 1995). Piirto (2000) reports on research that demonstrates a link between written and oral communication, suggesting that these skills are best learned and practiced together:

“...the two not only compliment[sic] each other, but elevate both oral and writing skills to a higher level than could be achieved alone. And significantly, this approach will not add another course to the already crowded curriculum.” (Piirto, 2000, 21).

Students certainly reported that the requirement to make an oral presentation of their written report encouraged them to ‘know their stuff’. The enthusiastic, positive response from students suggests that oral presentation could be incorporated more widely into assessment to improve both learning and student engagement. In Australian, reviews of engineering education from Williams (1988) to Johnson (1996) report on the perception that engineers are not good oral communicators. The results obtained here seem to dispel the belief that engineers dislike and shun public speaking, and are perhaps evidence that the ‘emerging engineer’ has just about arrived.

4.5.6 Group self-assessment
Various methods of assessing group work fairly are presented in the literature, ranging from not assessing group work at all, to using the common grade as the result for all group members (Rosser, 1998). The method employed in this instance (lecturer assigns overall group grade, which is then adjusted for individual students based on the group’s collective assessment of the relative contribution of each member) is reported as having the following benefits:
“This assessment conveys to students that the group work is important...that the group product as a whole will be assessed...and that the teammates’ perceptions of individual contributions also count.” (Rosser, 1998, 87).

It is interesting to note that, even though the positive comments suggest that the groups actively participated in the group self-assessment process, every single group assignment submission received indicated that all members contributed equally. This perhaps reflects the practical difficulty and discomfort (expressed in the negative student comments) in passing critical judgment on the performance of their friends, peers and work colleagues.

**4.5.7 Industrial interviews**
The positive comments show that this exercise was clearly valued and appreciated by the students. The slight decrease in support and increase in the spread of the score perhaps reflect the amount of time taken up in completing this exercise. The time required was the only negative aspect identified by the students. The benefits from student/industry interaction are self-evident and not just unidirectional:

“By introducing students to the actual processes and techniques in use, the learning process is elevated from the theoretical realm. Industry can benefit from this process as well, by better preparing future colleagues for the challenges they will be facing.” (Kraebber, 1993, 20).

The same source notes that such industrial interactions require effort on both sides, but as the results here suggest, the outcomes are worth the effort.

**4.5.8 Reflective journal**
The desired effect was reflection and critical evaluation. It appears that the way the journal was introduced did not achieve the desired effect, except in a few cases. This was the least ‘successful’ of the assessment activities, as perceived by the students, though many of the journal entries produced in class did demonstrate evidence of critical reflection and subject knowledge. Since critical reflection is one of the key means by which practising professionals develop and consolidate their experiential learning (Schön, 1995), it is intended to develop alternative approaches to better
introduce and exercise this important activity. Possible approaches are discussed below.

4.5.9 General
A number of new assessment activities were introduced into a final-year engineering practice unit. While the number of students participating does not permit wide generalisation, some observations can be made. Most of the assessment activities were rated by the students as having a moderate to high perceived value. Even where students described negative aspects of a particular method, they often described positive values as well. Many students commented that these techniques helped them to relate course theory to the real world and that their comprehension of the material was enhanced.

Significant changes in perceived value of assessment activities are noted in the preceding sections. It is interesting to note that the two assessment activities with which the students were most familiar (report writing and oral presentation) obtained high ratings for perceived value. While this perhaps indicates comfort with the familiar, the assessment activity initially indicated as the most valuable (industrial interviews) was one that students reported low levels of prior experience with.

Two of the assessment activities employed (peer / group self-assessment and reflective journals) were not successful, receiving both low ratings of perceived value (including a decrease in rating over the duration of the semester) and negative comments. The ability to give and receive constructive feedback/assessment to/from peers and to reflect critically on events and actions are valuable skills in professional practice. It is planned to modify the implementation of these assessment activities in future to improve the student perception of their value.

In the case presented, student groups were given the opportunity to collectively assess the relative contributions of each member, principally as a means of encouraging individual student effort. The literature on assessment in science and engineering suggests that the validity and student appreciation of peer assessment are increased by the provision of marking criteria that address multiple dimensions /
characteristics of the activity being assessed (Ormond and Merry, 1996). One specific approach is to provide students with a pro-forma marking sheet that includes marking criteria statements and a Likert-type five point grading scale on which to indicate their assessment (MacAlpine, 1999). The concept of peer assessment could be extended to peer marking of class-wide activities, such as the oral presentations, although the possible benefits need to be weighed up against the additional administrative work in collating and moderating a large number of student gradings.

Reflective thinking based on experiential learning is a key skill required for the lifelong learner and the socially mature engineering professional (Kolb, 1984) (Schön, 1995). Even though the reflective journal exercise described above was not wholly successful, the use of a reflective journal (due to the requirement to transfer thought processes into words) is thought to be a valuable tool in developing ‘reflexivity’ (Jolly et al., 1999), particularly for students (Collier, 1999). It has been suggested that the introduction of a reflective journal into a single point of the engineering curriculum may be less effective than if students encounter its use across the curriculum. The introduction of a reflective journal early in the students’ studies should be reinforced with additional later encounters (Jolly et al., 1999). Similarly, the introduction of a reflective journal at the final-year level (as described) without prior experience may not be most effective. It is noted that a reflective journal has since been introduced at first-year level as a tool for students to reflect upon their experiences of the transition into university studies. While there has not yet been time for students from this cohort to reach final-year, it is hoped that these students will have an increased appreciation of the value of reflection on action.

From this chapter it can be inferred that students value the attainment of generic professional practice skills, confirming the previous survey and literature conclusions that show that engineering students (amongst other stakeholders) rank generic professional practice skills highly. With the importance and history of Australian undergraduate engineering management studies documented and the expectations of important stakeholder groups established and characterised, the investigative phase of the first element of the project has been completed. The second principal project element is flexible delivery. The following chapter specifically addresses the topic of
flexible delivery, before the later chapters that consider flexible delivery of engineering management studies in particular.
5 - Flexible teaching and learning in engineering education

5.1 Introduction
Flexible delivery of engineering and technology education is now an essential component of the engineering education scene, catering for significant numbers of students who cannot attend traditional, full-time, on-campus studies. While flexible delivery of teaching and learning provides many benefits to both students and academic staff, systems of flexible delivery can also introduce many inflexibilities that are not part of traditional on-campus classroom teaching, and which may not be immediately obvious to those not involved in flexible delivery. This chapter is based on the research and practice of the author and presents the experiences and personal reflections of the author as an academic operating in an environment of flexible delivery of engineering and technology education. This chapter identifies the key challenges for flexibility in flexible mode engineering programs. The emerging issue of on-line course delivery is also addressed, both generally, and in the specific context of the application of on-line teaching technologies in engineering at Deakin University.

5.2 Flexible teaching and learning
The term ‘flexible’, when applied to teaching and learning has no single, agreed meaning. Attempts to define the term by reference to related terms like open learning and distance education are fraught with difficulty, as these labels also mean many things to many people. Telford (1995) describes flexible learning as:

“...another cover-all term [similar to open learning], inclusive of all forms of learning which, though institution-based, do not follow a laid-down pattern but are adaptable (in terms of time, place, method, etc.) to individuals or particular groups.” (Telford, 1995, 165).

Thomas (1995) suggests flexible learning is not necessarily synonymous with open learning:
“Flexible learning is not about producing variously deliverable learning packages or pick-'n'-mix courses to an otherwise undifferentiated mass market. It is about being prepared to configure all available resources, expertise and learning opportunities in the way that fits the learning purpose best.” (Thomas, 1995, 2).

Supporting the latter view, Gilham (1995) suggests that:

“...‘flexible learning’ appears to be a way of recognizing the myriad possibilities open to educators, as new ideas, new procedures and new media appear. ... It is increasingly necessary to create structures, organizations and management styles which can construct a flexible learning framework within which a wide range of opportunities exist and can be accessed by learners.” (Gilham, 1995, 54).

Highlighting the wide variance in the interpretation of flexible learning, Hodgson (1993) says:

“...flexible learning is a term used to describe many learning systems which could just as well be called ‘open’. The word ‘flexible’ tends to emphasize the individualized nature of the programme; that it is designed to offer the maximum opportunity to every possible learner. ... Flexible learning is no more tightly defined than is open learning and the terms are often used synonymously.” (Hodgson, 1993, 53).

For the purposes of the following discussion, the approach to flexible teaching and learning is as follows:

“Flexible teaching and learning...refers to an approach to education design and conduct based on the conviction that education is a recurrent, lifelong process, centred in the learner and the learner’s ability to make choices about the way learning occurs. ...Foundation principles include...identifying and catering for diverse characteristics of individual learners and groups; accommodating the particular circumstances of learners and teachers and the diverse environmental conditions for learning...and...promoting the appropriate use of technologies to
facilitate communicating, learning and teaching. Flexibility is recognised in the level of access to courses; the points of entry to, and exit from courses; the place, time and pace of study; the form and pattern of interactions among learners, teachers and resources; [and] the type and variety of resources to support study and communication...” (Deakin Centre for Academic Development, 1997, 11).

There is, of course, no reason why conventional-entry university students cannot take advantage of flexible teaching and learning, but the whole idea of flexible delivery arose from the need to cater for students from other than conventional backgrounds. The diversity of students who undertake flexible learning makes it impossible to describe the ‘typical’ flexible student. Students may study on-campus, off-campus or a mix of both modes. Students may study full-time or part-time. Students may study locally or at a distance, or even be based overseas. Students may come directly from secondary school or be mature-age on entry. In addition to their studies, students may have full-time or part-time employment. Students may be supported financially and/or time-wise by their employer, or may be self-sufficient. Students may have previously completed, partially completed or never undertaken post-secondary studies.

5.3 Flexible teaching and learning in engineering education

A key driver in the development of engineering and technology programs that incorporate flexible delivery is the culture of life-long learning that has arisen from the need to re-equip people with new skills resulting from organisational and technological change (Goldstein, 1997) (Marchio et al., 1997) (Evetts, 1998) (Keeling et al., 1998). As noted in Chapter 3, it is unrealistic to expect organisations to release staff to attend full-time, on-campus study; engineering and technology programs need to cater for mature-age students in the workplace who are upgrading their qualifications and skills. Many engineering and technology organisations worldwide are currently establishing links with higher education institutions to provide their staff with customised, flexible programs (Paquet, 1995) (Haynes et al., 1997) (Seaman, 1997).
As public funding for higher education worldwide is reduced, universities will find themselves in competition with private education providers. The ‘global village’ created by the Internet means that universities can offer flexible study programs based on the Internet and the World Wide Web (‘the Web’) to students anywhere in the world, 24 hours a day. To survive, engineering schools and the programs they offer will have to become more flexible, innovative and competitive.

For the purposes of this investigation, a ‘flexible learning’ program, as defined by Briggs (1995), is one that incorporates:

- a modular curriculum;
- policies for recognition of both formal and experiential prior learning (RPL);
- learning resources and tools, including computer-based resources, to support the learning needs and styles of all students; and
- means of facilitating two-way communication, especially through the use of computer-mediated communication (CMC) in addition to telephone-mediated and face-to-face communication.

It was also noted in Chapter 3, that with the introduction of engineering and technology degrees based on flexible delivery, there are a growing number of mature age students returning to study to upgrade their qualifications (Klus, 1995) (Kulandaisswamy and Mandke, 1995) (Lloyd et al., 1996). The majority of these students have previously studied and/or worked in the engineering workforce. This development poses some issues for the developers of engineering programs.

5.4 The Deakin engineering program

In Australia the standard entry into professional engineering practice is via the completion of a four year Bachelor of Engineering (BE) undergraduate course. The Deakin School of Engineering and Technology offers three year Bachelor of Technology (BTech), four year BE, Masters and Doctoral engineering programs in flexible delivery mode. The undergraduate programs are delivered on-campus, full-time for conventional entry students. Mature age students may study the programs off-campus and/or part-time. The programs are designed to articulate tightly with a range of national and international vocational, technical and diploma level
engineering study programs. A formalised system of granting advanced standing into the course based on RPL and workplace experience has been developed that permits block credit of up to two thirds of a Bachelor of Technology degree and up to half of a Bachelor of Engineering degree (Lloyd et al., 1996).

The entire undergraduate study program has been developed to address the requirements of a ‘flexible learning program’ as identified above. It incorporates:
- a modular curriculum;
- a formal assessment system for RPL based on granting advanced standing in appropriate course units;
- course units developed in print form, supplemented by an array of learning resources, including audio and video presentations, home experimental kits, computer-aided learning packages, remote (Internet-based) laboratory experiments and conventional laboratory work requirements; and
- computer-mediated communication systems, including e-mail, video conferencing, Web-based bulletin boards and Internet-based conferencing systems.

While the Deakin Engineering programs are labelled as ‘flexible’, the flexibility is principally in the place of study; because the course units are all available in off-campus mode, students can study at the place of their choosing, including interstate and internationally. The typical course program contains a small number of ‘elective’ units (up to 4 out of 32 units in a Bachelor of Engineering), but the balance of the course is prescribed. The content of each unit is prescribed; there may be some opportunity for students to select the topics of research-related assignments, but the learning objectives of each unit are fixed. While students exercise some control over the sequence of their studies, they must choose within the framework of prerequisite requirements. Students, both on- and off-campus, must generally conform to a semester timetable that includes fixed dates for submission of assignments and sitting examinations.
5.5 The inflexibilities of flexible teaching and learning

5.5.1 General

While flexible delivery of teaching and learning provides many benefits to both students and academic staff, systems of flexible delivery of education can also introduce many new considerations that are not part of traditional on-campus classroom teaching, and may not be immediately obvious to those not involved in flexible delivery. The follow sections identify the ‘inflexibilities’ that may arise under each of the elements of flexibility as identified above.

5.5.2 Modular curriculum

Most flexible learning systems employ some form of modular curriculum, where the entire program, year level, semester or even unit/subject are organised into discrete, separable sections of content. Modularisation offers the advantage of being able to customise a study program based on individual student needs, being able to rearrange combinations of content into alternate units of study or new programs/courses and it divides the content development task into smaller, more manageable chunks (Briggs, 1995). Brown and Saunders (1995) identify several of the challenges posed by modularisation of curricula. Two in particular are described here:

“While a major advantage with modularization is student choice, awards that are recognized by many professional associations are not allowed to stray far from a set route or pathway.” (Brown and Saunders, 1995, 101).

Engineering accreditation bodies around the world are moving toward systems based on demonstrated graduate attributes and competencies, and away from systems based on rigidly prescribed course contents. This is likely to increase course flexibility and student choice in all study areas. Modularisation does challenge the assumption about the importance of year-long integrated study programs, and it can lead to the compartmentalisation of knowledge, rather than integration across the full curriculum:
“...some staff worry about students not making crucial theoretical and methodological links between modules. ...This may be especially the case for combined or independent studies students where lecturers may not have planned or anticipated the choice of certain kinds of pathway or module permutations.” (Brown and Saunders, 1995, 101).

As many engineering schools move toward an integrated curriculum and/or problem based learning strategies, there is a challenge to flexible, modular engineering programs to provide a high level of integration across their many, potentially isolated course components. Course content and assessment tasks in individual modules/units should seek to place new knowledge in an engineering context and make explicit links to other areas of the student’s studies. One approach to explicit integration in a modular course is the inclusion of a ‘capstone’ unit that draws together and connects the wide range of knowledge and skills developed by students in their studies. A major engineering design project may be an appropriate context for such a capstone exercise (Noble, 1998).

The reasons many students find flexible study programs attractive are also the same reasons that can lead to students in these programs departing from a ‘normal’ study pattern (Morgan, 1997). Students with advanced standing exemptions and/or studying part-time may find progression through the normal course sequence is not possible because they have not yet completed a required prerequisite unit, or the only unit of study they can select for the current semester comes from a higher year level. Once you permit flexibility in a study program, it is only a matter of time before students trying to fill up their study semester will discover unusual combinations and sequences that are theoretically permitted by the course structure, but never intended. In an environment of modular study the hierarchy of unit prerequisites needs to be carefully designed and tested. At Deakin it is possible to find students enrolled in units from three year levels during the same semester. In such an environment, student cohorts fragment, with many students undertaking what is effectively an individual study program. This causes large problems for the scheduling of on-campus classes; where students are studying units from multiple levels in the course, it is virtually impossible to devise a timetable that does not contain class clashes. In
this situation, the only option the student may have is to switch to off-campus study mode to complete a unit that clashes.

5.5.3 Recognition of prior learning

Recognition of prior learning (RPL) plays a central role in flexible teaching and learning. In engineering education it is an essential part of creating pathways for engineering associates and para-professionals to articulate to higher occupational categories. Where either block or unit-by-unit credit for prior learning may be granted, similar considerations to modularisation regarding the student’s study path and prerequisites need to be taken into account. Where advanced standing is granted, academic staff must be confident the student possesses the required prerequisite knowledge for the balance of their study program, and that students will attain all the required attributes and skills by the completion of their studies. Under RPL schemes, it is common for mature-age students to be routinely exempted from a number of units (particularly those in the early years of the program) as advanced standing. ‘Essential’ course content should not be placed in units that are subject to exemption under RPL.

The process of assessing and granting RPL for each individual student claiming advanced standing may be difficult and time consuming. Judgements must be made about both the content of prior studies and the student’s mastery of the material. The experience of the author relates to relatively large student cohorts at Deakin, and the basis for assessing RPL includes:

- official unit descriptions published by institutions where prior formal studies have been undertaken;
- official academic transcripts of results from prior formal studies; and
- officially witnessed statements by applicants documenting their prior workplace experience and/or non-credentialed education and training and/or experiential learning.

This process can be protracted as the student seeks documentation of their prior studies and/or academic staff carry out investigations into courses completed by the student. The process can become particularly subjective where a student can
demonstrate prior mastery of a proportion of the content of a unit in the program they are applying for. Students would normally be exempted from course fees for those units where they are granted RPL, hence students can apply significant pressure for a favourable (financially) outcome in an advanced standing assessment. This process is facilitated by clear guidelines for the granting of RPL and developing a knowledge base of the permissible credit transfer from commonly encountered institutions and/or programs of prior studies. A key principle of RPL must be the granting of maximum exemptions that are consistent with the prospect of student success; there is no point in forcing students to undertake / duplicate unnecessary studies; conversely, it does a student no good to be granted advanced standing only to find they do not have the prerequisite knowledge required for success later in their course of study.

An important emerging trend in engineering education is the development of partnerships where institutions offering pre-university-level studies will collaborate with a higher education institution to provide a guaranteed articulation pathway based on block credit for studies in the former into programs offered by the latter. The collaboration can take the form of end-on RPL where pre-university studies include course design and assessment tasks that maximise advanced standing into a particular university program. More recent collaborations have involved active partnerships between the two institutions to create an integrated study program that includes simultaneous vocational-level and university-level studies leading to the award of two qualifications, typically in a shorter time frame than if a student undertook both study programs separately. Such integrated programs involve not only RPL by both institutions, but also effectively recognition of concurrent learning, as students will be undertaking studies in both educational sectors simultaneously.

As noted in Chapter 3, flexible learning programs with RPL mean a significant proportion of students may be mature-age and may have many years of experience working in the engineering workforce. The maturity and practical experience of mature-age students need to be acknowledged and catered for; they are looking for knowledge and skills that will underpin their current practice with theory and that they can apply in their workplace. One approach to contextualising the content of the
course is to include assessable assignment tasks that require the student to use their own workplace as a case study for the analysis and application of the course content. For example, it is possible to ask students to identify the approaches/methodologies used by their organisation in addressing issues and processes covered in the course. For on-campus students and those without workplace experience, an exercise in locating a relevant case study from the literature can provide the context for the analysis, as well as developing investigation and research skills.

5.5.4 Learning resources

The traditional distance learning resources are print-based study guides. Flexible learning materials take advantage of all available media including face-to-face lectures for on-campus students and those off-campus students that can attend, print-based materials, video and audio tapes, home experimental kits, CD-ROMs, residential sessions, computer programs and simulations, teleconferencing, e-mail and the Internet. Flexible learning employs many new and traditional teaching technologies, and the pre-eminent consideration in the selection of a teaching technology must be its appropriateness for the task required. For instance, simply placing existing print-based study materials onto the Web ‘because you can’, to ‘save money on printing notes’ or because ‘someone else is doing it’ is not an effective use of the teaching potential of the Web. The print medium is a valid and cost-effective means of delivering material that works well in print. The Web and other ‘new media’ should be reserved for appropriate applications that add value to the teaching and learning process (Emdad, 1991)).

There are many advantages in converting course material to print and/or other media. The course can be delivered to remote students who can study at the time of their choosing. Through the appropriate selection of a range of media, a range of learning experiences can be offered that replace, supplement or enhance traditional on-campus teaching. However, these advantages have to be weighed up against a new set of issues that arise in the development of flexible learning resources.

Preparation of flexible learning materials is very costly, principally in the time of academic and editorial staff to develop quality master courseware, but also in the
duplication and distribution of the material delivered to students. What works well in a lecture setting may not work well in print, and simply reproducing print material on a computer screen can also deliver a poor result (Emdad, 1991). Instructional design issues become critical in producing quality course material; either academic staff must become ‘experts’ in this field, or instructional design input must be closely incorporated into the course material development process. The typical approach to the production of flexible learning materials is to create a unit ‘team’ that incorporates expertise in academic content, instructional design and editorial review. The group has to be coordinated carefully to ensure the required outcome is produced in the required time frame. Careful consideration must be given to reconciling the desire to offer a particular unit or course in flexible delivery mode and the economic feasibility of recouping the cost of development.

The delivery of a course changes from a service that is created and delivered in real-time in a lecture, tutorial or laboratory setting, to a product that must be manufactured in a factory and delivered to remote customers. The analogy to industrial production is very close; the production of flexible learning materials involves the design of the product, the planning of production, the assembly of the required human, material and financial resources, the development and evaluation of product prototypes, the freezing of design changes, the commitment to mass production, the control of production, the storage of product inventories, the delivery of products to customers, after sales service to ensure customers received the correct product and are operating it correctly and a quality improvement process to ensure the product market share is retained and developed.

The move to an industrialised form of education delivery brings with it many of the issues that face other manufacturers of commercial products. Flexible learning materials must be developed long in advance of the time of delivery to allow for the time required for production and transport. In the author’s school, Unit Guides (which contain details of academic contacts, semester timetable, assignment questions, etc.) that accompany flexible study materials to be used by students in semester one must be handed over to editorial staff in the first week of August of the preceding year, that is, more than six months before delivery to students. This means
the running of the semester and the details of the unit assessment must be carefully planned long in advance, so the Unit Guides are accurate at the time of use.

To maximise utilisation of production capacity, as well as reduce peak production loads, it is not uncommon for more than one year’s worth of study materials for a particular unit to be produced in a given run. The ‘convenience’ of having stock on hand has to be balanced against the pressure not to make any revisions to unit materials for up to two years, lest existing study material stocks be rendered obsolete and have to be scrapped. An additional emerging delaying factor is the on-going effort required to maintain study materials after the initial development phase. Developments in technology, changes to the course structure or simple errata mean it is often desirable to update the course material. Unit revisions may have to compete with a widening array of new unit offerings under development and fixed or shrinking editorial capacity. Unit revisions may be limited (except in exceptional circumstances) to once every two years, with continuing pressure to push back jobs in the editorial schedule. The bottleneck here is not the ability of academic staff to produce course content, but the capacity of a small number of editorial staff to transform/revise the content produced by a much larger number of academic staff into finished courseware.

All of these practical factors related to inertia in the production system tend to limit the flexibility of the course content, and go against the trend in manufacturing toward responsiveness based on strategies such as just-in-time and concurrent development. There are some additional factors that limit the flexibility of flexible learning materials. While course material remains within the boundaries of the print media, educators generally enjoy some freedoms under the provisions of the relevant copyright laws in relation to print materials to be used for educational purposes. However, these freedoms normally apply to facsimile copying only; they do not extend to reproduction or transmission by electronic means (Learning Resources Services, 1998). Experience has shown copyright holders are reluctant to give permission and/or demand significant royalties for the use of educational material in electronic media such as CD-ROMs or the Internet. The issues related to copyright and intellectual property are addressed further later in this chapter.
Economies of scale are achieved by setting the same assessable tasks (ie. assignments and exams) for both on- and off-campus students. Once this is done, however, care must be taken to ensure all students have access to the same set of learning resources. The immediacy of the classroom means there is the opportunity to introduce additional material to enhance the learning experience. In a flexible program, if you wish to introduce any new core material that might later form part of an assessable task, this material must generally be reduced to print and then forwarded to off-campus students as well. The commitment to a static set of flexible learning resources works against any dynamic adjustments of the course content.

The more ‘flexible’ the learning resources are designed to be, the wider the range of students they must cater for and the more general they must become. For example, consider material covering occupational health and safety (OHS) initially prepared for manufacturing students principally from a single state or province. As the audience broadens to encompass other engineering disciplines, students may ask, ‘why are all the examples about manufacturing?’ As the audience broadens to encompass enrolments from other states, students may ask, ‘why are all the examples about the Victorian Occupational Health and Safety Act 1985?’ As the audience broadens to enrolments from other countries, students may ask for examples from their own localities. As the audience broadens, it is more difficult to cater for everyone’s individual needs.

There are additional factors that may limit the flexibility of flexible learning materials. Centrally produced study packages cannot cater for the infinite diversity of advice and support required by flexible learners; flexible learning packages are ‘on display’ for the world to see and judge, and hence may be overly heavy in content; and the behaviourist approach taken by many instructional designers leads to an ‘objective mastery’ approach to course presentation, with a closely prescribed sequence of learning goals that tightly controls student learning, which may tend to rigidly define and ‘close’ the curriculum (Paul, 1990).
5.5.5 Two-way communication

The addition of flexible-study mode students to the class can pose difficulties and bring benefits. Many flexible study students are mature-age, with experience of the engineering workforce; this can be a valuable asset and a real-world contribution to class discussion. Many flexible mode students will study off-campus, so to avoid isolation, ways must be found to ‘bring them into the class discussion’ (Barker et al., 1998). One-way communication can occur with printed study notes, but more effective learning can occur where there are means for student–teacher and student–student communication. Telephone, fax and e-mail communication can be very effective for point-to-point communication, and multi-point teleconferencing is possible. Recent developments in Internet-based, computer-mediated communication (CMC) have opened up new and rich opportunities for collaboration and communication at a distance (Weller and Hopgood, 1997). The increasing availability and adoption of Internet communications technology has seen the development of both asynchronous conferencing systems (such as newsgroups and bulletin boards) and synchronous conferencing systems (such as Internet Relay Chat and Web-based equivalents).

While it is difficult to generalise about the nature of communications with flexible mode students, personal experience suggests that while off-campus students generally seek communication with academic staff less frequently than their on-campus counterparts, the ‘quality’ or depth of their inquiries is typically more involved. Because off-campus inquiries often occur asynchronously (ie. the message arrives by fax, voicemail, e-mail, etc.), it can consume a significant amount of time to respond in written form (fax, e-mail, etc.) and/or make one or more phone calls to reach the student and respond in person.

One-to-one communication with remote students can be time consuming; but creating a one-to-many (ie. bulletin board) or many-to-many (ie. computer conferencing system) enhanced communication environment is an even greater undertaking. The new administrative load can involve learning how to operate the conferencing system, setting up the conferencing environment, supervision,
housekeeping, responding to direct inquiries or general questions from the group, moderation of discussions and production of summaries or digests of discussions.

While it is desirable to have timely communication with off-campus students generally, it is very important that assignments submitted through the post are assessed and returned with meaningful feedback in the shortest time-frame possible. The issues of delay in returning assignments and brevity of written feedback are perhaps the two most common complaints of off-campus students. If the university has a central off-campus operations department that handles assignment submissions and returns, then this may add several days to the turn around time for assignments. There is an imperative placed on academic staff operating in a flexible environment to process off-campus assignments in the shortest time practical.

While computer-based communication has been a positive development for flexible learning in that it has created an accessible, two-way discursive avenue for remote students, it is important to keep in mind that many students studying in the flexible mode are mature-age and they may have had limited exposure to computers before returning to study. Care must be taken to ensure any electronic communication systems offered to these students are easy to use and do not require students to make large financial outlays for specialised computer equipment.

5.5.6 Other issues

There is a large range of other issues related to flexible teaching and learning programs. Engineering, by its nature, contains a significant practical/vocational element. The provision of satisfactory laboratory/practical experiences for off-campus engineering students requires novel solutions (Walkington et al., 1994) (Weller and Hopgood, 1997). The flexible approach to laboratory work requirements at Deakin encompasses:

- exemption if the student can provide satisfactory evidence of prior experience;
- development of home experimental kits for appropriate units, such as electronics and basic materials experiments - home experimental kits have been used effectively in teaching science and technology fundamentals, it is even suggested
that they may increase learning by providing students with extra time to gather data and solve problems (Kenepohl and Last, 1997) (Carr, 2000);

- provision of intensive, on-campus practical sessions for several units at a time, delivered by the same staff/demonstrators who present practical sessions for on-campus students, normally timetabled on weekends, so off-campus students may travel, attend the university and complete their practical requirements infrequently - this approach is used widely in distance education programs requiring laboratory work (Ember, 1996); and

- individual arrangements where the student negotiates to conduct the required laboratory work using the facilities of their workplace or another educational institution closer to them.

A common element found in engineering undergraduate programs in many parts of the world is a requirement for students to complete a major design project and thesis in the senior year(s) of their study. At Deakin, on-campus students can complete this work under the guidance of academic staff, using university facilities and/or in conjunction with an industrial partner. Students studying off-campus may not be able to conveniently access the facilities of the university, but it is the experience of the author that these students are generally already employed by engineering organisations and normally tackle a real, work-based problem as their major project and are able to call on organisational resources that far exceed those available to their conventional on-campus counterparts, often leading to a superior outcome in terms of the significance of the project topic and the motivation of the student in completing the project work.

The awarding of advanced standing, carrying forward of incomplete results until off-campus students can fulfil unit practical/laboratory work requirements, frequent variations to individual enrolments and the possibility of a 16 year completion time for a part-time degree can all play havoc with systems of prerequisites and central student administration systems designed around conventional progress through a three or four year program of study. Flexible administration is required for flexible delivery.
5.6 Key challenges for flexible delivery in engineering education

Flexible delivery of engineering and technology education will continue to play an important role in opening up higher studies to students previously unable to access conventional study programs. While flexible delivery of teaching and learning provides many benefits to both students and academic staff, systems of flexible delivery of education can also introduce many inflexibilities that are not part of traditional on-campus classroom teaching. The key issues/challenges for flexibility in flexible mode programs in engineering and technology are not significantly different from those in any educational discipline seeking flexible delivery, they include the ‘pros’ and ‘cons’ listed in Table 15.

As engineering education incorporating flexible delivery moves further into the mainstream, an awareness of these issues will be crucial for those involved in flexible teaching and learning systems, as well as those considering implementing such systems.

5.7 - Current issues and limitations in using the Internet for teaching and learning

A key emerging issue in flexible delivery of education programs is the development and delivery of on-line study programs. Ryan (1998) notes that ‘flexible delivery’ and ‘Web-based delivery’ have become synonyms, as well as the ‘inevitability’ of on-line delivery in education:

“Time and tide are inexorable forces. Teaching and learning on-line is equally unstoppable...” (Ryan, 1998, 14).

Ubell (2000) notes a US government report estimating that by 2002 15% of American higher education is likely to be delivered on-line, and that in 1999 40% of the money spent on corporate training in America was for on-line education. The same source identifies engineers as key consumers of on-line education, based on the short half-life of technical knowledge and the need for the engineering workforce to continually refresh their knowledge and skills base, and on the fact that few engineers are likely to have the ‘luxury’ of attending classes on a physical campus. As noted
<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
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<tbody>
<tr>
<td>Flexible delivery opens up engineering education to non-conventional students.</td>
<td>Lack of a coherent/consistent definition as to what constitutes ‘flexible delivery’.</td>
</tr>
<tr>
<td>A modular curriculum is re-configurable to suit different student groups and may be developed incrementally.</td>
<td>Rigid course accreditation requirements may preclude course flexibility. Need to ensure integration of knowledge across course modules. Modularisation permits a wide range of study sequences.</td>
</tr>
<tr>
<td>Recognition of prior learning (RPL) acknowledges the value of prior formal studies and practical workplace experience.</td>
<td>Mature age students may be routinely exempted from Foundation studies. RPL assessments can be time consuming. Consistency is required in RPL assessments.</td>
</tr>
<tr>
<td>Flexible delivery may incorporate multiple media and remote delivery, catering to a wider audience and differing learning styles.</td>
<td>Teaching is changed from the delivery of a service to the creation of a product. Instructional design and editorial skills must be combined with academic expertise. The development of print-based, on-line and other material can be very expensive. Committing content to print or other media reduces flexibility and responsiveness. A wider audience means catering to a more diverse array of student needs/capabilities. More stringent copyright restrictions generally apply to media other than print.</td>
</tr>
<tr>
<td>Flexible delivery creates new opportunities for communication and collaboration via electronic channels.</td>
<td>Infrastructure/systems must be in place to support electronic communication. Students must have access to the Internet. Design and maintenance of on-line communication forums can be significant. Communication via post can introduce significant delays. Systems must be in place for remote delivery of required practical work. Part-time/remote study programs may cause problems for administration systems geared to conventional on-campus students. Academic staff development is critical in the success of flexible study programs.</td>
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previously, these same rationales apply to the mature aged undergraduate students in the Deakin engineering programs, and it is ‘inevitable’ that on-line delivery will play an increasingly important role for all undergraduate students.

This section acknowledges the new educational possibilities provided by the Internet, as well as identifying its current limitations as an educational medium. Issues of concern in using the Internet include equity and access, infrastructure considerations, intellectual property, development methodologies, implications for the delivery and administration of education and the relationship between the Internet and other new media in education, including audio/video tapes, computer aided learning software, videoconferencing and CD-ROM. While the Internet offers valuable opportunities to enhance all modes of teaching and learning, and it is likely that most of the current limitations of the Internet in this regard will be overcome in time, those developers currently pursuing or investigating the Internet as a teaching resource should be aware of the potential difficulties. This section draws on the experiences of the author in conventional and distance university teaching and in using the Internet as an aid to teaching and learning in engineering and technology, but the issues addressed apply generally to those using the Internet in education.

5.7.1 New educational possibilities

Despite certain misgivings, that will be identified, in part, here, there is little doubt that, just as computer and communication technologies pervade many aspects of our lives, computers have many roles to play in education. These roles include not only classroom teaching and learning experiences, but also administration, teacher training, the planning and development of educational material and general communications.

The ‘power’ of global networked communications when added to computer applications provides the enabling infrastructure for the Internet. The Internet offers a new range of educational technologies to educators that includes: electronic mail, file transfers, the multimedia capability of the world wide web (WWW), low-cost, desktop videoconferencing, on-line, interactive tutorials, real-time group
conferencing, remote access to laboratory experiments (Lemckert and Florance, 1996) and 3D interactive modelling.

For example, in engineering and technology education, computer applications can include computer programming, numerical analysis, computer simulation, computer aided design (CAD), computer aided manufacture (CAM), electronic communications, information retrieval and computer aided learning and assessment.

It is important to note that these new educational opportunities do not come without their own limitations, considerations and values. It is always important to remember that teaching technologies are not an end in themselves, only a means to deliver education: “Technologies do not teach; people do.” (Ingram, 1996, 31).

5.7.2 Equity and access

For a student to be able to participate in the new educational possibilities offered by the Internet, they must have access to the required computer hardware and software. On-campus students may have relatively easy access to computer labs and workplace-based students may be able to use the facilities of their employer, but off-campus students may have to purchase their own computer and communications hardware and software. However, simply having the requisite computer resources does not automatically grant access to the information super-highway. If one is unfamiliar with computers or the Internet, attempting to navigate this new medium can be frustrating and frightening. Brogan (1997) reports in a survey of 158 postgraduate students, composed of roughly equal numbers of on- and off-campus students, that even though more than 90% of students had access to a computer, 75% of all students stated a need for training in the use of the Internet.

Even when everyone is ‘on-line’, not everyone may have the same type of connection. On-campus students may have the benefit of high speed, dedicated networking, whereas the only option for an off-campus student may be a dial-up modem line that does not support the data transfer rate required for high quality interactive multimedia programs (Ingram, 1996).
Once a student has access to the required equipment, they may face the additional and on-going cost of service access. Those who require only on-campus use of the Internet in computer labs may pay no direct access costs. Students living close to the education institution may face only the cost of a local call to establish a modem connection to the Internet via their university. Students in remote areas may face more significant costs, perhaps even paying by the hour to a commercial service provider, to establish a reliable and reasonable speed Internet connection.

One approach to dealing with student access to the Internet is to simply make it a requirement for students entering a study program to have the necessary computer hardware and Internet connection. This may remove considerations of Internet access for those within the course, but it does nothing to address issues of equality of access to participation in education or the barriers to participation created by the adoption of new technology (Milone and Salpeter, 1996). Where only on-campus students are involved, close control can be exercised over both the computing environment and the material presented to students. In this scenario one possibility is to employ a self-contained intranet, where all the material is preset and preloaded by the system administrators and with no (or limited) connection to the external Internet (Long and Smith, 1996).

5.7.3 Infrastructure issues

Anyone involved in the administration and provision of Internet services will be aware of the large infrastructure costs, both capital and maintenance, necessary to provide the basic networking, computer hardware and software, staff training and staff and student user support required simply to operate in a networked environment - estimates of the ‘total cost of ownership’ of a PC operating in a networked environment range from US$1,500 to US$9,784 (Francis and Johnston, 1997). On top of this comes the cost of the development of educational software applications that run in this environment.

In fact, when it comes to information technology (IT) infrastructure, it is almost pointless to talk about ‘capital costs’, as to maintain the currency and performance of computer hardware and software, they will need to upgraded or replaced about every
three years. In this environment, capital costs effectively become maintenance costs. The product lifecycle of computer hardware and software ensures that owners of information technology infrastructure are tied to a treadmill of constant expenditure. One Australian university has recently announced that after an 18 month review of operations, it is to sell its 3000 computer workstations and lease them back in a deal that will include maintenance and upgrades, and will cost $10 million over three years (Anonymous, 1997a) and (Anonymous, 1997b).

Additionally, for higher education institutions the nature of the IT infrastructure required has changed dramatically over the last ten years. Where previously an individual school within a university may have maintained modest computer labs running a limited number of basic applications and specialised software, the current demand from virtually all subject areas for students to have access to powerful wordprocessors, spreadsheets, other specialised applications, multimedia and the Internet has seen a trend toward larger, centrally administered and funded computing laboratories providing a common suite of software applications.

The nature of off-campus computing access requirements have also radically changed. Initially, a university may have provided a limited number of dial-up modem lines that supported simple text-based terminal access. Then they found themselves catering for large numbers of off-campus students demanding full access to the Internet and other networked services. Many universities found themselves offering the same access services to their students that would be available on a fee-for-service basis from commercial Internet service providers (ISPs), but effectively they charged nothing for providing these services. Not surprisingly, their access services were constantly overloaded and a significant financial burden, to the point were several Australian universities considered introducing charges for dial-up access (Illing, 1996). At the point where universities were considering charging fees for dial up access, the obvious question was, “should universities be attempting to compete with commercial service providers by duplicating existing infrastructure?” One answer to this question can be found in the 1997 Information Technology Strategic Plan of Deakin University which assumed that by the year 2000, “90 per cent of all external access to Deakin University IT facilities will be via commercial
providers” (Anonymous, 1997c). Shortly after this, the policy was implemented and all modem access other than for staff and postgraduate students was removed, forcing undergraduate students to use ISPs for dial-up access.

5.7.4 Copyright and intellectual property

Historically, educators have enjoyed some freedom with the normal provisions of the Australian Copyright Act in relation to print materials to be used for education. However, these freedoms applied to facsimile copying only and did not extend to reproduction or transmission via electronic means (Course Development Centre Deakin University, 1998). Reproduction in a digitised form required the permission of the copyright holder. This requirement placed restrictions on the use of third party materials when the medium of transmission was the Internet, copyright clearance may have taken a long time to obtain, or not have been granted at all. Under the previous copyright legal framework it was not legal to simply take existing print-based course materials that contained items subject to copyright and digitise them for distribution via the Internet.

Throughout the period 1993-2000 the Australian Copyright Act has been under review; one of the issues given consideration was the relationship between digital media and copyright. In a 1994 report of the Copyright Convergence Group (CCG) (a group formed in 1993 to propose legislative changes to the Copyright Act) one of the recommendations was that a ‘technology neutral’, broad based right to authorise transmissions be introduced into the Act (Copyright Convergence Group, 1994). Flowing from this recommendation, the Australian Copyright Act was put under review by the Copyright Law Review Committee (CLRC). The review was a response to concerns that the Act was out of step with technological developments, such as electronic publication and distribution via the Internet, and that it had become unnecessarily complex (Copyright Law Review Committee, 1995).

In August 2000 the Australian federal parliament passed a range of amendments to the Copyright Act, which came into effect in March 2001. Amongst these amendments were the ‘Digital Agenda Amendments’. The major areas of change relating to digital technology include:
“...
• a “broad-based technology-neutral” right of communication to the public;
• the “extension” into the digital environment of special exceptions for libraries and educational institutions;” (Australian Copyright Council, 2000, 1).

The intention of the amendments was to permit the digitisation and transmission via digital means, including the Internet, of copyright material that would have been permitted in print form only under the previous ‘fair use’ copyright provisions that applied to educational institutions. However, as of the time of writing, these amendments to the Copyright Act are only beginning to come into effect, and as there are no precedents for the legal issues arising from the new amendments, the types of materials and the modes of storage and transmission consider ‘acceptable’ or ‘fair’ by copyright holders is still to be tested. Within these constraints, it appears that the use of the Internet for education will be freed from the previous restrictions and be placed on par with print as a medium for the transmission of educational materials.

In addition to the concerns about the use of third party material on the Internet, there is also the related issue of protection of the intellectual property embodied in documents that may be transmitted over the Internet. This issue is of particular importance to the developers of educational courseware, as a substantial investment may have been made in development of these materials. Traditionally, course materials were printed, affording at least some protection against misappropriation (other than direct photo-reproduction) in that the material would have to be manually re-keyed or otherwise accurately digitised before it could be reproduced. When documents are transmitted using the Internet, particular via the WWW, a complete electronic version of the source file is sent to the remote computer so that it can be reconstructed on the computer screen. This file can be easily captured by the remote computer, providing the reader with the entire source material for the document already in electronic form.

5.7.5 Development methodologies and issues

The Internet is an all-embracing label for a suite of computer network communication services that includes e-mail, newsgroups, Telnet, file transfer protocol (FTP), Gopher, wide area information server (WAIS) and hypertext transfer
protocol (HTTP). These services primarily support the transfer of text-based information and files. The hypertext transfer protocol supports the transfer of multimedia elements including text, graphic images, audio files and animations, and is the underlying transport mechanism of the WWW. It should be noted that the development of educational materials for use with the Internet is almost exclusively confined to the WWW, this is due to WWW offering support for text, graphics, animation and other multimedia elements, as well as permitting a high level of interactivity. When approaching the development of materials (educational or otherwise) for the Internet, it is important to be aware of the available development methodologies.

It is possible to perform a straightforward and relatively automatic conversion of existing print-based materials, particularly if they already exist in electronic form. Many wordprocessors now have options to save documents in hypertext markup language (HTML) format, the file format required for transmission over the WWW. While this approach offers cost advantages, there may be significant disadvantages, depending on the particular application. If the original material contains items developed by third parties and incorporated in a print-based form under the guidelines of Copyright Act, then copyright clearance may have to be sought for each item if it is to be transmitted electronically via the Internet. Any items in the source document that are not in electronic form, such as third party figures and tables or hand drawn diagrams, will have to be digitised or electronically re-drafted for inclusion.

Where the source material is print-based, a direct conversion for display on a computer screen may produce a result that is less than visually appealing. What looks good on paper, may not work well on a computer screen. For example, the average computer screen is not long enough to display an entire page at once, requiring students to continually scroll down while reading. Significant reformatting of the source document may be required to appropriately adapt it to the new medium. The literature related to the readability of computer screens suggests that while the presentation of text on a computer screen does not significantly reduce comprehension, it does impact on reading speed, with the printed page being easier to
read than a computer screen, and larger screens being better that smaller screens. Additionally, most readers report a preference for reading the printed page over a computer screen.

Where a document is to be reformatted or authored anew for transmission over the WWW, there exists the opportunity to create or adapt it to take advantage of the additional content elements that are supported by the WWW, such as colour graphics, audio, video, animation and interaction. Where learning resources are being developed for both print-based and electronic delivery, the requirements and possibilities of both media need to be considered.

What the preceding paragraphs have been inferring is that designing learning resources for the WWW requires an additional set of skills and resources that includes design of screen layout, hypertext markup, development of multimedia elements such as audio and video clips, WWW document editing software and access to the WWW/Internet. Editorial and instructional design staff who are experienced in the development of print-based materials will require additional training to create materials that use the WWW effectively. Since the advent of wordprocessors and laser printers, just about anyone can create a professional looking printed page, but not everyone can present the content in such a way that leads to effective learning. The same can be said for the WWW, with the same wordprocessor, just about anyone can easily create a WWW page, but there are still few people with the knowledge and experience to create WWW learning materials that have a sound basis in educational theory and take full advantage of the new educational possibilities offered by the WWW.

If Internet-based learning resources are to be developed without the use of dedicated editorial or instructional design staff, then the task must fall to specialist consultants or project officers, or to general academic staff. If the task is to be delegated to academic staff, then they too will require individual training and development if meaningful, effective and consistent results are to be obtained. To simply expect that academic staff with a wide variation in computer and Internet literacy and perhaps
limited knowledge of instructional design principles will magically produce quality Internet courseware, without appropriate training, is unrealistic.

Apart from human resources, effective and efficient development of WWW-based learning materials requires specialised and dedicated computer hardware and software. While it is possible to create WWW pages using a standard wordprocessor, there exist specialised WWW authoring programs that provide an integrated development environment encompassing text, graphics, colour, sound and animations, as well as document control and management functions. To develop full multimedia applications requires the addition of specialised hardware to a standard computer, including optical scanning capability, audio and video recording and playback, CD-ROM, large amounts of memory, mass storage and a network connection to the Internet.

5.7.6 Implications for the delivery and administration of education

Once a university, or even an individual has decided to employ Internet-based teaching technologies, there are other issues and problems that are likely to arise. Some of those considered above include, will student access to the Internet be compulsory/essential?; are the necessary hardware, software and network resources in place?; if not, will they be provided centrally by the university, or must the faculty/school provide them? Similar questions need to be answered regarding staff training and development; who will fund the capital and on-going system costs?; and what development methodology will be used to create the learning materials? A fundamental consideration in answering most of these questions relates to the nature of the development exercise, is it intended as a ‘one off’, special project to create an item, or items of specific courseware, or is it intended as an on going and ‘normal’ part of the courseware development and delivery process?

The development of WWW-based learning materials is similar in nature to conventional software development. This suggests that the difficulties experienced in accurately estimating software development costs (Kusters et al., 1990) are likely to apply to WWW courseware development as well.
While many of the same difficulties arise when using the WWW for teaching both on- and off-campus students, at least the on-campus computing environment is normally under the control of the teaching institution. The nature and variability of the off-campus computing environment, which is normally under the control of individual students, leads to many problems, some of which are described here. Given that one of the primary justifications for pursuing developments in this medium is the ability of the Internet to bring education to students, via the communications network, regardless of their location, then the organisation of effective off-campus computing is crucial.

First of all, off-campus students have to get connected to the university’s network, which normally means a dial-up modem link. Communications software and details of the procedure for connecting to the university’s network must be provided to students. Normally, there will also be some bulletin board or other user interface to the network that the student must use to access specific subject-related and general resources, documentation for using this system must also be provided. Some of this documentation is likely to be produced centrally for universal distribution and the rest will be produced by faculties/schools to deal with course-specific details. All of this must be coordinated and delivered to off-campus students.

Anyone who has been involved with off-campus computing will be aware of the wide variety of problems experienced by students attempting a modem dial-up connection. Such problems are typically caused by incorrect configuration of the student’s modem and/or communications software, or because the student simply does not have the computing knowledge necessary to understand the directions given in the documentation provided. But, they may also be caused by problems as difficult to diagnose as corrupted files on the floppy disks used to distribute connection software to students.

Problems of this nature can provide difficulties for a computer ‘expert’ on the spot, so it is not surprising that they can be extremely difficult to diagnose by ‘remote control’ when a student calls the university computer centre and says, “I can’t get it to work!” . Where the system is comprised of centrally supported computing
infrastructure, special resources developed by the faculty/school and the remote student’s equipment, attempting to pin down the location and nature of a problem can be virtually impossible. If the student cannot access expert assistance locally, it is not uncommon for such problems to remain unresolved, with the student simply never getting ‘on-line’.

Once initial courseware materials are developed and students are connected to the network, the issue of administration of on-line teaching must be considered. Authors of WWW learning materials normally include contact information and in keeping with the nature of the medium, this is often in the form of an e-mail address. If the number of students accessing the material is large, the author may find themself inundated with questions, requests and comments sent via e-mail. While some of these electronic requests will replace inquiries that would have traditionally been made by the telephone, fax or post, the ease with which students can create and send an e-mail message is likely to lead to a net increase in their demand on academic staff time. Where electronic communication is designed to be an integral component of the course, such as a discussion group, bulletin board or e-mail list, the new administrative load can involve supervision, housekeeping, responding to direct inquiries or general questions from the group, moderation of discussions and production of summaries or digests of discussions. Even where there is no planned electronic discussion and the materials are simply placed on the WWW for students to access and read, there is still a need to keep this information up to date and evolving if the desire is for students to visit the information regularly. A static WWW site is soon recognised as such, and students lose the motivation to regularly check back to see ‘what’s new’.

There exist a number of integrated applications that provide a framework for the development and management of on-line (particularly WWW-based) teaching and learning resources. These applications include Learning Space from Lotus, Virtual-U from Virtual Learning Environments Inc, WebCT from WebCT Educational Technologies and Top Class from WBT Systems. The typical features provided by these systems include operation via the WWW, e-mail, file exchange, newsgroups, self-assessment, testing and progress tracking tools for students, course planning and
management, instructional design tools, grading and results analysis and security tools. The benefits of these systems are their integrated development and management environment and their abstraction of the user from the underlying WWW and database technologies.

5.7.7 Relationship with other new media

‘Multimedia’ and ‘new media’ are somewhat overused terms in education, but the various technologies that fall under these headings can be valuable teaching tools (Satran, 1994). By definition, ‘multimedia’ refers to a communications system that combines more than one media, this then includes audio and video tapes, interactive computer programs, computer aided learning (CAL) packages and videoconferencing. The WWW is generally included as one of the new media, so a comparison of the WWW with some other of the new media is valuable.

Where the aim is to provide learning resources to off-campus students without the requirement that the students have access to a computer or the Internet, then print-based materials supported by audio and/or video tapes are likely to be the preferred option. Compared to the WWW, print materials have limited interactivity and cannot be updated without forwarding revised materials to the student.

Virtually all of the functionality that can be provided by a dedicated CAL package or a computer simulation program (such as animations and interactivity) can now be provided by the WWW, thanks to recent developments in the WWW programming language Java. If students do not have access to the Internet, then dedicated computer programs have the advantage that they can be distributed on a floppy disk or CD-ROM. The advantage that the WWW has here is that WWW applications are independent of the computer platform that the students uses, whereas dedicated CAL/simulation programs must be developed for each possible platform the student may use.

Currently, if videoconferencing is to be employed, the best results are still obtained by using a dedicated video-conferencing system that is based on special image compression hardware and high-speed digital communications channels, such as
ISDN. However, recent developments in WWW-based videoconferencing, using only a Pentium computer, standard telephone line, video compression card and low-cost camera are impressive to say the least (Adams, 1996), and will bringing videoconferencing for education applications into the realm of individual students.

If an application requires large amounts of digital information to be accessed, searched or transferred in a short time, then CD-ROM technology is currently probably the best solution. All of the same functionality can be delivered with the WWW, but data transfer rates across the Internet are (currently) no match for having a CD-ROM installed locally in your computer. Additionally, a local CD-ROM does not suffer from availability problems caused by network failures or modem drop-outs and does not slow down to a snail’s pace because large numbers of users are trying to access it at the same time. The downside of the CD-ROM is that the large amounts of data on the disk are as permanent as a book and revisions require the issue of another CD-ROM, whereas a WWW site can be updated frequently and quickly. New, hybrid applications are combining the best characteristics of both CD-ROM and WWW technology - large amounts of static data can be placed on a CD-ROM, along with automatic links to WWW sites that contain software updates and/or the latest supplementary information (Pardhu, 1996) (Hyams, 1996).

This section presented a series of issues and limitations for consideration regarding the use of the WWW in teaching and learning applications. There is no doubt that time, and with it developments in technology, custom and the nature of education will overcome many of the current limitations and render irrelevant many of the current issues associated with using the Internet in teaching and learning. The passage of time will, no doubt also bring new problems and new issues to be considered. For those currently working in this area, the limitations and issues identified herein are important and must be considered. The consideration of on-line teaching technology has so far been generalised. The following section examines in detail the use of on-line technologies in the support of teaching and learning in engineering at Deakin University.
5.8 - The evolution of on-line teaching and learning in engineering at Deakin University

5.8.1 Computer-based learning in the School of Engineering and Technology

From the beginning of the new School of Engineering and Technology at Deakin University in 1991, computer-aided learning (CAL) tools were intended to be a key part of the School’s flexible delivery strategy. For the development of stand-alone CAL programs to be distributed to students on a floppy disk, the School has used the Authorware (Macromedia Inc., 1993) development environment. CAL packages cannot replace real-world, practical experiences, but they can be used to support teaching and learning, particularly for off-campus students, and to assist in ensuring that the limited time available for hands-on, practical sessions is used most effectively. An example of this is the METROLOG program (Ferguson and Wong, 1995) - see Figure 17. This graphical program introduces students to the operation of precision measuring equipment before they use it in the laboratory, so they can spend more time making real measurements.

![Figure 17 - Screenshot of METROLOG CAL program](image-url)
In 1994 the School commenced negotiations to acquire a computer-managed learning (CML) system. It was envisaged that this system would not only be used to develop, store and deliver on-line learning materials, but also manage the complex array of student administration information required by the School. After a long process of evaluating systems, agreement was reached in 1995 to purchase a CML system. At about this time the School also began investigating the Web as an educational medium. After a period of trials and modification of the CML system to meet local requirements, a working prototype was installed in mid-1996. By the end of 1997 the CML system had been consigned to history. This was due to a combination of factors, including; technical problems with the system; lack of specific resources to manage the system implementation; planned changes to the central University student information database; and the emergence of the Web as an educational delivery medium.

With the new student information database promising to handle the course administration functions, the focus in the School shifted to the Web for the delivery of on-line educational materials (Elgueta et al., 1995). It was also realised that the Web served many other functions, including internal staff communications and as one of the public faces of the School (Green, 1996).

5.8.2 From individual efforts to formal, centralised control of the WWW

During 1996 a small number of staff piloted the development of Web pages to support their teaching (Baliga and Palmer, 1996) - see Figure 18. The results, while promising, were of varying visual appearance and instructional soundness; the efforts of ‘lone early adopters’ are often not successful (Green, 1997). Without wishing to restrain academic freedom and individual developments, it was realised that standardisation of format and review of content were required to ensure quality of content and appearance. The School developed guidelines for Web pages that included templates for consistency of appearance and a peer review process for the educational content. While the School maintained its own Web server, IT Manager and Multimedia Developer, the increasing number of staff wishing to use the Web as an adjunct to teaching and learning soon created a bottle-neck in the timely delivery of content on the Web. It was quickly apparent that University edicts such as “every
unit/class shall have a Web page” (a statement that, without further elaboration, is virtually meaningless) would not be practical or sustainable under the existing development model.

5.8.3 The costs of information technology

The School found itself in the position of having to maintain its own computing laboratory, as the central information technology (IT) division could not / would not support the specialised hardware and software required in the engineering field. This laboratory had been setup in the early 1990s and by 1997 was significantly out of date and urgently in need of a major upgrade. At this time, the Schools of the University were also responsible for the provision of computing hardware and software for their staff, and in the School of Engineering and Technology this infrastructure was also in need of a major upgrade. An investigation during 1997 revealed that the School was spending in excess of AU$100,000 per annum maintaining its IT infrastructure, even though there was no formal IT cost line in the School budget – a position that was not well understood due to the ad-hoc funding of
IT and a position that was not sustainable. Research from the USA at the same time period reported that less than one third of campuses had a financial plan for IT and more than 70% of campuses funded IT expenses through one-off budget allocations or special appropriations (The Campus Computing Project, 1997). The same US source reports in 1999 that while 61% of US higher education institutions now have a strategic plan for IT, the majority still fund IT via ‘budget dust’, or special year-end allocations (The Campus Computing Project, 1999).

By 1997 the computer hardware provided by the central IT division was more in line with the requirements of the School. While the School’s IT costs were increasing, the University was spending much more. In early 1997 the central IT division launched the Deakin University Workstation Scheme (DUWS), under which a moderate standard PC or MAC workstation with a full complement of software could be supplied to staff at a fixed lease cost per year. The IT division would contribute half of the lease cost and administer the consolidation of the lease arrangements across the University through a single external supplier.

During 1997 discussions between the School and IT division resulted in the School computing lab being handed over to the IT division. At the commencement of 1998 the outdated lab equipment was replaced with new computers at no cost to the School, and a shared arrangement between the School’s IT manager and the IT division for the management of the laboratory configuration was negotiated. The main drawback for the School was that the computer lab was now open for general access to all students, no longer exclusively for the use of engineering students. However, this has not proven to be a significant problem.

In late 1997 it was decided that the School would participate in the DUWS program. By mid-1998 all staff had DUWS workstations, providing staff with maintained computing infrastructure for a known, fixed cost per year, and at an overall cost that was significantly less than the ad-hoc spending under the previous regime.
5.8.4 Experiences with grant funded development projects

The School has received grant funding from various sources for the development of on-line teaching and learning resources. The CML system mentioned above was partially funded by a seeding grant from the University. Funding was also received to pay for a short-term staff appointment to develop a Web-based courseware delivery system. Unfortunately, the time lag in appointing a suitably qualified person willing to relocate for a short-term contract meant that the project schedule was always running behind, and while a model courseware delivery system was developed, it was never mainstreamed. Both the CML and Web courseware projects focused on developing/implementing delivery mechanisms, rather than content. Time and reflection has shown that the educational value actually lies in the content, and that the content must be stored in a flexible enough manner to be able to be re-used when the particular delivery system becomes obsolete and retired.

The School has also been successful in competitively bidding for grants from the former Committee for the Advancement of University Teaching (CAUT) (a national grant funding body in Australia) and its successor body the Committee for University Teaching and Staff Development (CUTSD). In 1995 funding was received for the development of a CAL package to simulate mechanics experiments. In 1996 funding was received for the development of a fluids experiment operated in real-time over the Internet (Lemckert and Florance, 1997) - see Figure 19. In 1997 funding was received for the development of a system to operate manufacturing equipment in real-time over the Internet (Ferguson and Florance, 1999). While these projects have been successful in demonstrating the development processes involved and the utility of the end products as tools to assist teaching and learning, there are some issues to be considered. These large development projects consume significant amounts of money and time. While the grant funding pays for direct project resources, there is also a large burden placed on the infrastructure of the hosting School. In the case of the School of Engineering and Technology, these large and prominent ‘lighthouse’ on-line projects have consumed both equipment and the time of academic and support staff in the development of relatively specialised products that, in reality, will only ever benefit relatively small student groups. This effort may have been better
Figure 19 - Screenshot of fluids experiment operated remotely over the Internet

directed toward developing reliable and easy-to-use infrastructure and systems to support the mainstream use of on-line technologies in teaching and learning.

In a University-wide effort to encourage the adoption of on-line teaching methods, the School received a modest amount of funding from the University in 1998 under the On-line Teaching Enhancement Project (OTEP). The majority of this funding was distributed in AUSS$1,000 parcels to approximately ten academic staff to undertake a diverse range of small-scale, on-line developments. The positive outcomes of this exercise included:

- understanding how academic staff approach on-line developments;
- appreciating the resource requirements for on-line developments;
- highlighting the process issues in on-line developments;
- permitting the School to explore a number of on-line technologies in teaching and learning on a pilot scale; and
- resulting in several key infrastructure resources to support on-going on-line teaching and learning in the School.
The approach of dispersing the funds into a large number of relatively small projects, while permitting experimentation with a range of approaches at the pilot level, had a number of drawbacks, (also reported elsewhere in (Green, 1997)) these included:

- enthusiastic/ambitious project proposals from academic staff all had to be scaled back to a scope that was practical;
- the nominal funding amount of $1,000 per participant was really too small to achieve significant outcomes, results were only obtained by significant in-kind technical and development contributions from the School’s multimedia developer;
- the $1,000 was seen as a ‘token’ reward for the effort required, leading (in some cases) to problems in sustaining enthusiasm for the individual projects over the time frame required to achieve outcomes; and
- a large amount of coordination time was required to administer a large number of small projects.

5.8.5 Managing / resourcing the development of on-line material

The development and maintenance of on-line teaching resources that are consistent, coordinated and up-to-date creates management and resourcing issues. In the context of the School, which has in excess of 100 individual study units on offer, the goal of on-line teaching and learning resources for each of these units represents a significant challenge.

It is essential to have a standard ‘look and feel’ for unit Web pages. Students and others accessing the pages need to be able to develop an understanding of what they will find in the unit Web pages and where. Those contributing the content also need to know what is expected and in what form it is required.

The key to sustainably managing large numbers of Web pages is to avoid having to manually create the source code for each page. Changes in curriculum, syllabus, staff, timetables, etc mean that hand-coded Web pages quickly become out of date, requiring modification. Modern Web server technology (such as Active Server Pages (ASP)) means that Web pages can be created on-the-fly using templates to describe
the page layout and a database to provide the actual page content. An entire Web site for 100 units could conceivably consist of a few ASP template pages describing the structure of the pages for each unit and a database of unit information. As long as the currency of the information in the database is maintained, the Web pages will be up-to-date. Ideally, the database(s) used should be the organisation’s standard one(s), this will avoid the expense and dangers of duplicating data. Figure 20 shows a Web page that presents the description for the study unit SEB121. The hypertext markup language (HTML) code for this page does not exist anywhere; it is created in real-time when the page is called up by a browser. The ASP system creates the Web page by populating a standard template for all unit description pages with the particular data for the unit SEB121 that is contained in the curriculum database.

Figure 20 - Screenshot of a Web page generated from an ASP template and database content

While relatively static administrative information should be easy to extract from existing organisational databases, the academic content for each unit does need to be individually authored. This process can be facilitated by the provision of tools to
collect the content from academic staff and deposit it in databases, from which Web pages can be automatically generated. Such tools can be based on a Web interface, providing a familiar environment for most academic staff. If the entry of academic content is easy, academic staff are more inclined to participate. Figure 21 shows one such Web-based tool developed in the School to implement a ‘class news’ function. Academic staff simply select their unit code from a drop-down box, all existing news items are displayed and can be edited, or a new news item can be created. The results are saved in a database and will be displayed the next time a student accesses the class news for that unit. Figure 22 shows the resulting class news item as it appears to the student when it is generated on-the-fly using a master ASP template for class news pages and the content stored in the class news database by academic staff.

Figure 21 - Screenshot of a Web-based form to assist academic staff to author Web content

Other Web-based tools developed to assist staff to author content within their unit Web pages include a tool to enter and manage links to other Web resources located on the Internet and a tool to upload and manage files that are then available for
students to download from the unit Web pages. Three key elements of the philosophy behind these home-grown Web tools are:

1. to provide an easy-to-use avenue for staff to create Web content without needing any knowledge of HTML or server/network architecture;

2. to develop tools that are custom made to suit the requirements of teaching in the School, rather than having to adapt teaching methods to suit an off-the-shelf Web courseware solution; and

3. to adopt an incremental/evolutionary approach to on-line teaching and learning that avoids large investments in proprietary technology that is prone to obsolescence due to advancements in technology.

There is no doubt that there has been increasing pressure from many quarters on academic staff in the School to ‘go on-line’, but it is felt that this process has been significantly eased by the availability of the Web tools provided. In 1997 no unit had a Web page, in semester one of 1998 six units had a Web page, in semester one of
1999 19 units had a Web page and in semester one of 2000 32 units had a Web page. Annualised, this now represents approximately 50% of the units offered by the School having some form of on-line support available provided by academic staff on a principally voluntary basis, and the proportion is expected to continue to increase.

If the content of the unit Web site can be continually expanded / enhanced, it offers more value to students and addresses the problem of static, unchanging Web pages, for which students and other viewers quickly lose interest in and don’t bother to return to. A strategy employed in the School is to make the opening screen for each study unit Web page to be the class news - see Figure 22. In this way, the first thing that students see is the latest information relating to their studies, and as long as academic staff update the class news content, the page will change regularly. Once again, starting from zero in 1997, the number of unique students accessing unit Web pages have been increasing proportionately with the increasing availability of unit Web pages. In semester one of 1998 335 unique students access were recorded across all available unit Web pages, in semester one of 1999 976 unique student accesses were recorded and in semester one of 2000 1720 unique student accesses were recorded. As students are normally enrolled in up to four units, it is difficult to determine the proportion of students actively using the provided unit Web pages, but the number is rising.

5.8.6 Student access and equity

As one of the driving principles of the new School of Engineering and Technology was increased access to engineering and technology education through flexible delivery, there was an on-going concern about the adoption of computer-aided and computer-based teaching technologies, and the possibility of this being a barrier to access. Software packages were always developed for the lowest common-denominator computer system of the time, and while on-campus students have free access to computer labs and the Internet, there was an ever-present concern regarding the ability of off-campus students to access teaching and learning materials placed on the Web. Some of this concern was laid to rest in 1998 when a survey of commencing engineering students (see Chapter 6) revealed that, for off-campus students:
• 100% had access to a computer;
• 95% were regular users of a computer;
• 85% had access to the Internet;
• 75% regularly used e-mail; and
• 70% regularly used the Web.

Even though being off-campus and on-line may mean a slow, modem-based Internet connection and hourly charges from an Internet Service Provider, the survey results suggest that off-campus engineering students are well placed to take advantage of on-line support of teaching and learning.

5.8.7 Staff development and cultural change

The experience of the School with the introduction of on-line teaching and learning technologies is that academic staff do not magically become developers of high quality, educationally sound, on-line learning materials, neither do they instantly become proficient users and enthusiastic advocates for the new technologies. When confronted with the command to go on-line, staff may initially claim they don’t know what the new technology is capable of. They may then claim they don’t know how to use it. They may then claim they don’t have the time for any additional work. Finally, they may claim that on-line teaching and learning is inferior to classroom teaching and learning. These may all be genuine concerns for the staff member involved.

The failure to accompany the introduction of new technology with appropriate staff development will mean expensive investments may largely lie idle or be used ineffectively. The development of on-line teaching and learning resources cannot be yet one more task lumped onto the workload of academics; there must be sufficient time allowed for the task. If the proponents of new teaching technologies cannot offer a convincing case and concrete examples for the value and benefit of new approaches, why should a sceptical academic staff member suddenly be converted to the new path? Following the installation of IT infrastructure, the priority must be staff training and curriculum development (Kress and Hafner, 1996). IT infrastructure is a prerequisite for success, but unless academic staff genuinely
believe that new technology will make a significant difference in teaching and learning, success is unlikely (Morrison, 1998).

Interestingly, on-line teaching technologies may provide part of the answer to the staff development problem that they cause. The on-line medium itself can provide an effective avenue for academic staff development in the application of new technologies in teaching and learning, particularly as a medium for peer-to-peer, collegial support and assistance (Spratt et al., 2000).

5.8.8 A sustainable on-line content development model

The School of Engineering and Technology at Deakin University now has several years of experience with various on-line technologies used in the support of teaching and learning. Based on this, the author offers the following model of sustainable development for the future.

The content to be delivered to students is as important as the delivery mechanism, and the delivery mechanism may be superseded; care must be taken not to over-invest in the medium itself. Care must also be taken to avoid imposing a rigid structure on existing teaching processes – the delivery system should adapt to the education process, not the other way around. The Internet / Web is a viable medium for a variety of teaching and learning content and is likely to remain so. The Web provides support for incremental development of on-line teaching tools that can be enhanced and expanded as needed. For consistency, quality and economy, central control needs to be exercised over the form and appearance of on-line material. The never-ending cycle of computer hardware and software upgrades requires that IT costs are controlled; leasing is a practical strategy for dealing with technology obsolescence and unknown IT budgets. Large-scale, lighthouse development projects may create a high profile for the use of on-line technologies, but may distract, if not detract, from the development of the infrastructure and smaller-scale successes required for the mainstreaming of on-line teaching and learning. A key methodology to sustainably manage the task of providing Web-based support for large numbers of units/classes is to automate the generation of pages containing routine/static information. For the generation of Web pages containing academic content, tools are
required that simplify and minimise the additional workload placed on academic staff. On-line developments do not have to aim for the lowest common denominator to achieve equity and access; most off-campus students (in engineering and technology) are regular users of the Internet. Staff development and exemplars of existing projects are essential items in equipping and enthusing academic staff to participate in on-line teaching and learning. The key to successful on-line teaching and learning is to create flexible systems that can accommodate changes in content, technology and student needs.

This chapter investigated flexible teaching and learning in engineering, initially from a general perspective, then addressing on-line flexible delivery via the Internet and then finally on-line flexible delivery in Deakin University’s engineering programs. While many critical issues in flexible delivery were identified, the key emerging issue in flexible delivery is on-line delivery. This chapter provided an academic/institutional perspective on the computer-based and on-line technology that plays an important role in the design and delivery of teaching and learning in engineering at Deakin University. It has been shown that this technology can be managed effectively from an institutional perspective. However, if this technology is not effective/attractive/accessible from the student’s perspective, then it serves little purpose. The following chapter investigates the student perspective of computer-based flexible delivery in detail via two case study evaluations of the application of on-line technology in the context of an engineering management unit at Deakin University.
6 - Computer applications in the flexible delivery of engineering management education

6.1 Introduction

It has been shown that flexible delivery is an important element of modern engineering education and that computers and on-line technologies can be used to facilitate the flexible delivery of teaching and learning. The uses of computer and communications technologies in teaching and learning are widespread and varied. Just as computer and communication technologies pervade many aspects of our lives, computers have many roles to play in education. These roles include not only classroom teaching and learning experiences, but also administration, teacher training, the planning and development of educational material and general communications. The use of computers in education is particularly relevant to engineering education, as the computer has become one of the central tools of the practising engineer, whether it be for CAD, project planning, process control, budgeting, data communications or software development.

This chapter addresses educational computer applications, specifically relating to the flexible delivery of engineering management education. The aim here is to investigate the viability and efficacy of on-line teaching technologies in engineering management studies, by:

- identifying student readiness to adopt on-line technologies in their education; and
- evaluating the effectiveness of on-line technologies in management studies.

Case studies from the professional practice of the author are presented in the form of surveys of student cohorts to assess the stated objectives.

As required by university ethics procedures, all of the surveys conducted for the project were anonymous and voluntary. To encourage good response rates under these conditions, the questionnaires were kept as simple and straightforward as possible. Factor analysis, internal reliability analysis and piloting were not performed. The details of each of the three questionnaires are presented in the following sections. A wide range of data are presented and analysed in the surveys, some of them quantitative and some of them descriptive. Many results are not
quantitative, so there is a limit to the statistical analysis that can be performed. For other data parametric statistical inference testing is used where it is appropriate. Correlation analysis underlies the identification of many parametric statistical inference tests.

6.2 On- and off-campus computer usage in engineering education

As outlined in the previous chapter, computers and information technology play an important role in engineering education at the School of Engineering and Technology, Deakin University, Australia. Hence it was considered important to understand the computer usage patterns of students at the commencement of their undergraduate engineering studies. If students do not have ready access to computing infrastructure, do not have computer skills or do not have an inclination to use computers, then educational delivery strategies (in engineering management or any other area) premised on computer technology are destined to fail. Experience has shown that there are significant demographic differences between on- and off-campus engineering student groups. It was thought that the differences in the student groups might also lead to differences in computer usage patterns between the groups. While on-campus students have access to well appointed computer laboratories, the level of computer access that off-campus students have was largely unknown. A philosophy of flexible delivery must effectively encompass and provide for both on- and off-campus students groups. To address these questions a survey of commencing on- and off-campus undergraduate student computer usage in engineering education at Deakin University was undertaken.

6.2.1 Computers in engineering education at Deakin University

The use of computers is an integral part of all the engineering study programs of the School of Engineering and Technology at Deakin University. Of the computer applications identified above as used in engineering and technology education, only computer-aided assessment is not yet employed in the Deakin University engineering and technology programs. The university centrally supports and provides (on a CD-ROM) at no cost to students, application software for e-mail, computer conferencing, virus protection, bibliographic database management and access to on-line databases. On-campus students have access to computer labs where all required software has been installed. Where a software package is to be used in a study unit, a key
selection criterion is the availability of a low-cost, student edition of the package, so that purchase of the package can be made compulsory for off-campus students. This may involve negotiation with software suppliers for special student pricing, or for the ‘leasing’ of software that off-campus students must return at the end of the semester. A strategy for off-campus software provision that was used in the past, but is no longer employed, was the use of centrally hosted, text-based applications that were accessed via a terminal emulation program and the Internet. The requirement to be connected to the network to run the application and the inherent limitations of a text-based interface have rendered this approach obsolete.

The aim is that off-campus students are not required to attend the campus to complete their studies that require the use of computer applications. Computer programming exercises are coded, compiled, run and debugged remotely by off-campus students. Program listings and evidence of program performance would typically be submitted for assessment. Similar requirements exist for numerical analysis and computer simulation exercises. CAD exercises require students to draft their drawings on their computer remotely and submit their drawing files on floppy disk. CAM exercises require students to develop and validate their machine control programs remotely and submit them on floppy disk so that actual parts can be machined in a flexible manufacturing cell. A recent development at Deakin University allows students to submit their CAM files via the Internet directly to a computer that controls the flexible manufacturing cell and then watch live video, via the Internet, of their part being machined (Ferguson and Florance, 1999). The School of Engineering and Technology has also developed a number of special purpose computer aided learning (CAL) packages covering areas as diverse as taking measurements with a micrometer to understanding moral decision making.

6.2.2 Methodology
The sample student population chosen was the enrolment in the level one unit SEB121 – Fundamentals of Technology Management. SEB121 is common to all study programs in the School of Engineering and Technology and is taken by most on- and off-campus students in the first semester of the first year of their studies.
The topics covered in SEB121 include the history of technology, its relevance to society, ethics and the professional responsibilities of engineers and technologists, library research skills, written and graphical communication, oral presentation, the concepts and basic principles of management and the basic principles of quality. As a core, level one foundation unit, the student enrolment captures a diverse group of students who will eventually study in undergraduate technology courses leading to the award of a bachelor degree at professional engineer or engineering technologist level, in disciplines including manufacturing, mechatronics, environmental, civil, electrical, electronics and computronics. A questionnaire delivered to this student group should provide a comprehensive snapshot of the computer usage patterns of engineering and technology students at the commencement of their studies.

While engineering and technology students will be required to become proficient computer users, and in some cases computer programmers, during the course of their studies, the unit SEB121 itself is not computer intensive; students are required to wordprocess their written reports totalling approximately 3000 words, use a CAL package that leads them through a moral decision making framework, use a Web-based multiple choice quiz bank and access on-line information sources in the completion of their reports.

The questionnaire was administered at the commencement of the first study semester in February 1998, the enrolment of SEB121 at this time included 104 on-campus students and 37 off-campus students. Class time in the very first class was set aside for on-campus students, and the questionnaire was mailed with a reply-paid envelope to all off-campus students at the commencement of the semester. A copy of the survey is included in Appendix F - Questionnaire used to ascertain computer usage patterns. As required by University research ethics procedures, participation in the survey was anonymous and voluntary.

The questionnaire included five sections, with questions addressing the following areas:

1. **General demographic information.** Age. Gender. Mode of study (on-campus/off-campus).
2. **Computer usage patterns.** Have you used a computer before? Do you use a computer regularly? What type of computer do you use? (PC/Mac/other). How many hours per week (on average) do you spend using a computer?

3. **Access to computers.** Do you have access to a computer? Who does the computer belong to? (you/your family/your employer/a friend/other).

4. **Internet usage.** Do you regularly use e-mail? Do you use your own e-mail account? Do you regularly use the World Wide Web? Have you ever created a Web page? Do you have access to the Internet? Where do you have access? (home/work/school/university/other).

5. **Other general, descriptive questions relating to computer usage.** What do you think computers are most useful for? What task do you use computers for most? What computer program do you use the most?

### 6.2.3 Results

#### 6.2.3.1 Response rate

From the total unit enrolment of 141 students a total of 76 questionnaire returns were received, giving an overall response rate 53.9%. The on-campus response rate was 54.8% (57 returns out of 104) and the off-campus response rate was 51.4% (19 returns out of 37).

#### 6.2.3.2 Demographic information

The overall proportion of female respondents was 22.4% and the overall proportion of male respondents was 77.6%. The overall age range of respondents varied widely, with significantly different distributions between on-campus students ($M = 18.9$ years, $SD = 2.3$) and off-campus students ($M = 31.9$ years, $SD = 8.7$). See the Discussion section below for a detailed discussion of these results.

#### 6.2.3.3 Computer usage

Table 16 gives the percentage of respondents who indicated they had used a computer before and the percentage of respondents who indicated they use a computer regularly. For those respondents that indicated they used a computer regularly, Table 16 also gives the mean and standard deviation of the reported average hours per week computer usage. Of those respondents that indicated they used a computer regularly, overall, 91.8% of respondents indicated they used a PC and 8.2% indicated they used a Mac. For on-campus students who were regular
computer users the response rate was 88.6% for PCs and 11.4% for Macs, for off-campus students it was 100% for PCs.

6.2.3.4 Computer access
Overall, 96.0% of respondents indicated they had access to a computer. For on-campus students the response rate was 94.6%, for off-campus students it was 100%. Of those that indicated they had access to a computer, they were further asked to indicate the source of their computer access. Figure 23 shows the indicated source of student computer access for on- and off-campus students.

![Diagram showing the proportion of respondents by study mode and source of computer access.]

Figure 23 - Indicated source of student computer access for on- and off-campus students
### 6.2.3.5 Internet usage

Table 17 gives the percentage of respondents who indicated they use e-mail regularly. For those respondents that indicated they use e-mail regularly, Table 17 also gives the percentage of respondents that use their own e-mail account; the balance of regular e-mail users gain access using someone else’s e-mail account. Table 17 also gives the percentage of respondents who indicated that they use the WWW regularly, the percentage of respondents who indicated they had previously created a WWW page and the percentage of respondents who indicated that they have access to the Internet/WWW.

**Table 17 - Reported Internet usage for on- and off-campus students**

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>On-campus</th>
<th>Off-campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use e-mail regularly</td>
<td>40.8 %</td>
<td>29.8 %</td>
<td>73.7 %</td>
</tr>
<tr>
<td>Use own e-mail account</td>
<td>90.0 %</td>
<td>93.8 %</td>
<td>85.7 %</td>
</tr>
<tr>
<td>Use WWW regularly</td>
<td>46.1 %</td>
<td>38.6 %</td>
<td>68.4 %</td>
</tr>
<tr>
<td>Created a WWW page</td>
<td>10.5 %</td>
<td>8.8 %</td>
<td>15.8 %</td>
</tr>
<tr>
<td>Have access to the Internet</td>
<td>84.2 %</td>
<td>84.2 %</td>
<td>84.2 %</td>
</tr>
</tbody>
</table>

Of those that indicated they had access to the Internet/WWW, they were further asked to indicate the source of their access. Figure 24 shows the indicated source of Internet/WWW access for on- and off-campus students.

### 6.2.3.6 Descriptive questions

As only the top three responses for each of the descriptive question are reported here, the on- and off-campus responses are separated so that the larger absolute number of on-campus responses does not swamp the off-campus responses.

In response to the question, ‘What do you think computers are most useful for?’, the three most frequent responses from on-campus students were, assignments (29),
information (16) and saving time (5). For off-campus students the three most frequent responses were, word processing (4), communication (3) and information (3). In response to the question, ‘What task do you use computers for most?’; the three most frequent responses from on-campus students were, assignments (37), information (5) and work (3). For off-campus students the four most frequent responses were word processing (7), communication (3), information (3) and Internet (3). In response to the question, ‘What computer program do you use the most?’; the three most frequent responses from on-campus students were MS Word (20), MS Windows 95 (7) and MS Office (7). For off-campus students the three most frequent responses were MS Office (4), Netscape (4) and MS Word (3).

6.2.4 Discussion

6.2.4.1 Response rate
As is required by university research ethics procedures, completion of the questionnaire was anonymous and voluntary, yielding an overall response rate of 53.9%. Comparison of the main demographic characteristics suggests that the sample respondent group were not significantly different from the total class population. While age data on individual students was not accessible due to university research ethics procedures, the mean respondent age for both on-campus students ($M = 18.9$ years, $SD = 2.3$) and off-campus students ($M = 31.9$ years, $SD = 5.1$).
8.7) is closely aligned to the result from a survey for a different purpose on the next commencing class for the same unit; on-campus ($M = 18.5$, $SD = 2.1$), off-campus ($M = 34.4$, $SD = 7.2$). Data on student gender is available and the proportion of female respondents (22.4%) is not significantly different from the actual proportion of female students in the class population (16.7%) ($t = -0.48$, $p > 0.63$). Likewise, the proportion of on-campus (75.0%) and off-campus (25.0%) respondents is not significantly different from the distribution of study mode in the class population (on-campus = 81.4%, off-campus = 18.6%) ($t = 1.04$, $p > 0.30$).

6.2.4.2 Demographic information
The overall female student response rate was 22.4% (24.6% for on-campus students and 15.8% for off-campus students). The on-campus female response rate is somewhat higher than the estimated female participation rate in Australian engineering undergraduate studies of approximately 15% (extrapolated from (Roberts and Lewis, 1996)). This may be due to the presence of an ‘environmental engineering’ discipline study stream at Deakin University, which has shown to attract greater than average numbers of female students (Roberts and Lewis, 1996). The low proportion of female students in engineering studies means that the absolute number of female respondents is relatively small, suggesting caution in inferences about sample characteristics based on gender.

The observed age distributions of on- and off-campus students are significantly different, on-campus mean age = 18.9 years and off-campus mean age = 31.9 years ($t = -6.31$, $p < 0.00001$). The observed differences are as expected. On-campus students in the Deakin University engineering program are principally those entering directly from secondary school with a nominal age of 18 years at the commencement of their studies (these ‘conventional entry’ students are not normally permitted to study in the off-campus mode until they reach 20 years of age). Off-campus students are principally mature age (defined as 20 years or older at the commencement of their studies (Briggs, 1995)), with a wide variation in age, previous studies and personal circumstances. It is their personal circumstances that lead to mature age students normally studying in the off-campus mode; many of these students live remotely from the University and/or have full-time employment and/or are returning to study to upgrade their qualifications to improve their career prospects and/or are
participating in employer-sponsored study programs. It is proposed that the
differences in personal circumstances between the on- and off-campus student groups
lead to many of the observed differences between the groups in the questionnaire
responses discussed below.

6.2.4.3  Computer usage
All on-campus students reported having used a computer previously, while only 5.3%
of off-campus students indicated they had not used a computer before. This is
perhaps an indicator of the high rate of penetration of computers into secondary
schools and into society in general.

Even though 100% of on-campus students reported prior use of a computer, only
77.2% designated themselves as regular computer users. This finding agrees with
78% of students reporting themselves as ‘confident’ computer users in an Australian,
on-campus, undergraduate applied science course (Ash, 1996). All off-campus
students who reported prior use of a computer also reported themselves as regular
computer users (94.7%); this may arise from off-campus / mature age student
computer usage being strongly associated with employment (there are other
indicators of this below). The rates of reporting of being a regular computer user for
on-campus students (77.2%) and off-campus students (94.7%) are significantly
different ($t = -2.32, p < 0.024$).

Questions such as ‘Do you use a computer regularly?’ or ‘Do you regularly use e-
mail’ are open to subjective interpretation by questionnaire respondents. What one
student considers a high level of computer usage may be considered average or low
by another student. A measure of confidence that students have responded to such
questions on a rational basis can be found in the significant difference in reported
average weekly hours of computer usage between the group of all students that
identified themselves as regular computer users ($M = 13.21$ hours per week) and the
group that identified themselves as not using computers regularly ($M = 0.14$ hours
per week) ($t = 7.16, p < 2 \times 10^{-9}$).

Of the 81.6% of all respondents who indicated they were regular computer users, the
vast majority (91.8%) indicated the computer type they use to be a PC. 8.2% of on-
campus students indicated they regularly use a Mac, while no off-campus students reported Mac usage. The reporting of Mac usage by younger students recently from secondary school may relate to the association of the Mac with education and home computer markets, while the domination of PC usage reported by off-campus students may relate to the association of the PC with the corporate computer market, particularly in the fields of engineering and technology. No respondent reported using a computer type other than a PC or a Mac.

While the average computer usage for off-campus students is almost four times that for on-campus students \( (t = -4.3, p < 0.0003) \), the variation in usage reported by both groups is wide. The mean value for on-campus students was 6.0 hours per week, the median reported value was 3.0 hours per week and the most commonly reported value was nil hours per week. The modal value for on-campus students suggests that many of this group are not initially enthusiastic users of computers and will require induction in the use of computers and demonstration of the value of computers as a tool to assist in their academic work. The mean value for off-campus students was 23.3 hours per week, the median reported value was 20.0 hours per week and the most commonly reported value was 40 hours per week; the modal value here again suggesting a link between computer usage and the nominal working week for mature age students in full-time employment.

6.2.4.4 Computer access
Overall, a significant majority of students reported having access to a computer. The on-campus response rate was 94.6%, for off-campus students the response rate was 100%. A similar, high rate of student computer access (90% to 100%) was reported in the study identified previously (Ash, 1996). For on-campus students, a high level of both access to computers (94.6%) and previous use of computers (100%) does not correspond to an equally high level of regular usage of computers (77.2%). This finding agrees with a prior finding that even when college/university level students were provided with computer accounts and an incentive to use the computer (lecture notes, homework questions, handouts, etc delivered via e-mail), more than a quarter (27.3%) elected not to access the computer-based learning resources on offer (Zagorsky, 1997).
It is interesting to note that all students, both on- and off-campus are provided a computer account through Deakin University, and all on-campus students have access to a large number of both PC and Mac workstations in a number of laboratories, and yet, a small number of on-campus students (5.4%) believe that they do not have access to a computer. This perhaps represents the fact that at the commencement of their studies, some on-campus students are still orienting themselves to university life and do not yet fully appreciate what resources are on offer to them. As suggested above, an induction program in computing for on-campus students could be beneficial. Another interpretation found in the literature is that some students do not necessarily view the physical presence of on-campus computer labs as equating to ‘having access to computers’. Althaus (1997) notes that students who do not have their own computing equipment must make special trips to computer labs and vie with other students for access to computers. Interestingly, the same source quotes an engineering student explaining their lack of participation in a class computer exercise as follows:

“I didn’t dislike it, it was just inconvenient for me. I am an engineering major, and spend 30-40 hours/week doing problem sets. I do not have a computer w/modem in my room, and I only go to the computer lab to solve problems or write programs.” (Althaus, 1997, 170).

For those respondents indicating they had access to a computer, Figure 23 shows the differences in the source of that access between on- and off-campus students. Off-campus students are largely self-sufficient in computer access (84.2%), with a small proportion indicating their family or employer as their source of access. By comparison, nearly two thirds of on-campus students list either their family (44.2%) or university (19.2%) as the source of their computer access. The distributions of source of computer access are significantly different between on- and off-campus students ($\chi^2 = 18.24, p < 0.0012$). For on-campus students, combining family (44.2%) and self (30.8%) computer access sources gives an estimate of 75.0% of conventional entry students having access to a computer at home. This compares to the recently reported figure of 68.2% of students (in a large group of 16-19 year old
students in the United Kingdom) having access to a computer at home (Selwyn, 1998).

Computer access at home has been linked to academic performance and attitude to information technology (Selwyn, 1998). If the indicated source of student computer access of ‘you’ and ‘your family’ are taken to indicate access to a computer at home, then indicated access to a computer at home is (not surprisingly) strongly associated with computer usage; 88.1% of regular computer users had access to a computer at home and 91.2% of those with access to a computer at home reported themselves as regular computer users. Comparing reported average hours per week computer usage against the reported source of computer access shows that (other than for those students who report their source of computer access as their employer) those with access to a computer at home are the highest non-occupational users of computers.

While it is recommended to students entering the undergraduate engineering programs at Deakin University that they have access to a computer, it has not been made a mandatory requirement for entry on the basis of equity and access; principally due to concerns that off-campus students may not necessarily have access to and/or be able to afford a computer. The results of this research project suggest that for the students who elect to undertake engineering studies, off-campus access to computers is not a significant issue.

6.2.4.5 Internet usage

The use of the Internet as an educational medium is expanding, with justifications ranging from institutional cost savings to enhanced student access to education (Manjouriides, 1997). Two important Internet services for teaching and learning are the WWW (for the delivery of multimedia content) and e-mail (for basic electronic communication).

The regular use of e-mail was significantly different between the two student groups ($t = 3.72, p < 0.0008$); 29.8% of on-campus students reporting using e-mail regularly, for off-campus students the reported rate was 73.7%. The much higher usage rate for off-campus students may be due to their adoption of electronic communication as a means of overcoming distance barriers to communication in their studies and/or their
prior exposure to e-mail as a means of corporate communication. A majority of regular e-mail users have their own e-mail accounts, though 14.3% (2 out of 14) of regular, off-campus e-mail users report using someone else’s e-mail account. It is noted that only female off-campus students reported using someone else’s e-mail account, but the small sample size does not lend itself to drawing meaningful conclusions. It can be suggested that the use of e-mail lists or other mechanisms for the delivery of course-related information to on-campus students via e-mail is not likely to be very successful. Anecdotal experience in the School of Engineering and Technology at Deakin University suggests that while e-mail is not a reliable method for contacting on-campus students, it is used very effectively as a communication medium by a significant proportion of off-campus students.

Overall, slightly less than half of the respondents indicated that they were regular users of the WWW. As for e-mail usage, there was a significant difference between the reported regular usage of the WWW between on- (38.6%) and off-campus (68.4%) students ($t = -2.39, p < 0.023$). The difference in the use of the Internet may be related to the differences in the source of Internet access reported by the two student groups, as discussed below.

Only a relatively limited proportion of students reported previously creating a WWW page (on-campus = 8.8%, off-campus = 15.8%). This suggests that while overall approximately half of students may be regular users of the WWW, only a small proportion have competence and experience with the technology (hypertext markup language) that underpins the WWW.

Both on- and off-campus students reported a high proportion of access to the WWW (84.2% for both groups), so it is not a lack of access that make on-campus students relatively low users of the WWW. Considering the reported proportion of regular use of the WWW above, it appears that while more than 80% of off-campus students with WWW access are regular users, only 46% of on-campus students with WWW access are regular users.
For those respondents indicating they had access to the WWW, Figure 24 shows the differences in the source of that access between on- and off-campus students. The distributions of source of WWW access are significantly different between on- and off-campus students ($\chi^2 = 18.74, p < 0.00031$) and this may explain the differing usage patterns. More than 80% of off-campus students have Internet access at home, making it potentially easier for them to access the Internet at a time of their choosing; though access from home would normally involve a cost to the student in access charges from a commercial Internet service provider. Conversely, only 27.7% of on-campus students reported Internet access at home; the majority of on-campus students reported that their place of access was the University. While the University provides on-campus students with free access to computer workstations and the Internet, this access is only available while the student is on-campus with free time between classes and other study activities. The lack of access to the Internet at a time and place of convenience to on-campus students may account for their lower reported rate of regular use of the Internet/WWW.

For this student population, it seems clear that off-campus students will be in the best position to benefit from the provision of Internet-based resources in teaching and learning. While computer-based resources can be of great benefit in enhancing the distance learning experience, all efforts need to be made to assist on-campus students to access and use such resources if they are to share in the benefits as well.

There are important considerations in the use of the Internet by students that go beyond mere access to computing facilities and the Internet. Even when everyone is ‘on-line’, not everyone may have the same type of connection. On-campus students may have the benefit of high speed, dedicated networking, whereas the only option for an off-campus student may be a dial-up modem line that does not support the data transfer rate required for high quality interactive multimedia programs (Ingram, 1996). Additionally, simply having the requisite computer resources does not automatically grant access to the information super-highway. If one is unfamiliar with computers or the Internet, attempting to navigate this new medium can be frustrating and frightening. A survey of 158 postgraduate students, composed of roughly equal numbers of on- and off-campus students, reports that even though
more than 90% of students had access to a computer, 75% of all students stated a need for training in the use of the Internet (Brogan, 1997).

6.2.4.6 Descriptive questions
As an adjunct to the quantitative data collected, qualitative data was collected in the form of open-ended responses from students, based on personal perceptions, to a series of descriptive questions relating to their computer usage.

Based on responses to the question, ‘What do you think computers are most useful for?’, both groups of students indicated that computers were a tool for written communication and a source of information.

The responses to the question, ‘What task do you use computers for most?’, were consistent with the previous question. On-campus students clearly identified the ‘electronic typewriter’ function of the computer in producing schoolwork. Off-campus students also identified word processing as their most used function, but they also identified the Internet as an important use of computers, agreeing with their reported regular usage of the Internet at almost twice the rate of on-campus students.

The responses to the final question, ‘What computer program do you use the most?’, were again consistent with the previous two questions. Wordprocessors and other office tools were reported highly by both groups. The use of the Internet by off-campus students was again signalled by their inclusion of an Internet browser in their list of most used computer programs.

A previously cited study identified that students were primarily using computers in their studies for word processing (Ash, 1996). Previous research indicates that game playing is a popular use of computers by students, particularly amongst younger students at home (Kirkman, 1993). However, in response to the descriptive questions above, only one (out of 19) off-campus student indicated that they used computers for ‘play’ and only seven (out of 104) on-campus students indicated that they used computers for ‘entertainment’ or ‘games’.
6.2.4.7 Other remarks
There has been a significant, long-standing, wide-spread, but declining gender gap relating to computer usage and access to computers (particularly at home) reported in the literature on computers in education (Durndell and Thomson, 1997) (Dorman, 1998). While differences based on gender were observed in the overall response rate to questions about where students have access to computers and to the Internet, the differences were not large, and the relatively low representation of female students in engineering studies (approximately 15%) makes it difficult to draw robust statistical inferences. It could be proposed that the prerequisite studies in mathematics and science at secondary school level, that are generally required for entry into engineering studies at the higher education level, mean that students entering engineering studies, regardless of gender, may already have some affinity for science, technology and computers.

The survey was administered early in the first semester of the first year of the study programs of most of the participating students. Due to exposure to computers as both a learning tool and a tool of trade of the practising engineer, it is expected that their computer usage habits will change significantly over the first year of their studies and, indeed, over the duration of their study program. An understanding of the computer usage patterns of students entering engineering study programs is essential for the design of the course to provide undergraduate students with the appropriate computer skills that they require both to study and to practice.

The results obtained in this section indicate that the students entering engineering courses at Deakin University are competent and ready to use computers and on-line technologies in their studies. While the context of this survey was an engineering management unit, it principally sought to establish the general capability, capacity and readiness of students to use computer-based technology in their studies. The following section moves a step forward and examines the application of computer and on-line technologies specifically in the context of flexible delivery of an engineering management study unit.
6.3 On- and Off-campus engineering student usage of a computer conferencing system in an engineering management unit

The literature suggests that computer and on-line technologies offer value in education generally, and also for management education in particular. Accepting that engineering management education is a close relative of general management education, what can be found regarding the application of information technology in management education?

Webster and Hackley (1997) note the widespread use of technology-mediated distance education in both undergraduate and graduate business education. Among the advantages they cite for this development is:

“Another advantage of using information technology in education is that students are introduced to and take advantage of the very technologies that business are using to gain competitive advantage...Business schools are under increased pressure to graduate students with experience with these emerging technologies...” (Webster and Hackley, 1997, 1282).

Leidner and Jarvenpaa (1995) argue that the effectiveness of IT in management education is closely related to the learning model employed. Technologies such as asynchronous communication systems that create virtual learning spaces and provide students with a degree of control over their learning experiences are best suited to constructive or collaborative learning models (such as those often employed in management studies), rather than in objective learning approaches used in the transmission of factual information to the student:

“It can be argued that such technologies would do little more than frustrate learners in an objective environment - forcing them to search for the right answer when it would be easier to be told.” (Leidner and Jarvenpaa, 1995, 280).

This suggests that computer conferencing might not be particularly effective in engineering science elements of engineering studies, but might offer value in the management components of the same course.
The section reports on the introduction of a computer conferencing system into an engineering management unit at Deakin with relatively large numbers of both on- and off-campus students and an investigation undertaken to characterise both the usage and the perception of the conferencing system by both student groups. It was hypothesised that the differences in the two student groups would lead to differences in computer usage patterns between the groups. It was also hypothesised that the experience of using a computer conferencing system would change the attitudes of students to computers and learning. This section presents an investigation to test these hypotheses and the results obtained.

6.3.1 Computer conferencing in education
Educational applications of computer conferencing have been reported for more than two decades (Zinn, 1976) (Berge, 1997). Cifuentes et al. (1997) conclude from the literature that computer conferencing:

“fulfills an assortment of functions...bulletin board, public tutorial, individual project, free-flowing discussion, structured seminar, peer counseling, collective database, group product, community decision making, and intercommunity network”;

...it,

“provides an environment conducive to collaborative learning and teaching and equal opportunity for communication...promotes self-direction by encouraging learner autonomy”;

...and it,

“is appropriate for virtual classroom discussions, group projects, keeping personal interaction journals, and socializing” (Cifuentes et al., 1997, 178).
An Asynchronous Learning Network (ALN) is defined as a teaching and learning environment located within a computer-managed communication system (Hiltz and Wellman, 1997); a ‘virtual classroom’. Hiltz and Wellman (1997) further suggest:

“ALNs consist of a set of group communication and work “spaces” and facilities constructed in software....A virtual classroom [referring to a trademarked name of the New Jersey Institute of Technology] is both an instrumental group — in which students and instructors want to accomplish goals — and a community — in which students exchange emotional support, information, and a sense of belonging. ALNs are best at enriching educational options when they serve as a way to create the feeling of a true “class”…” (Hiltz and Wellman, 1997, 46)

A natural application of computer conferencing and ALNs is in the creation of a learning community for students studying off-campus. Research by the U.K. Open University into their ‘tutorial support model’, where computer conferencing was used to replace telephone, letter and face-to-face communication, showed that:

“...students value the interaction with other students, as much as interaction with the tutor. They find it valuable to compare notes with their peers, to chat about issues tangential to the course and to create the kind of community usually only found on campus.” (Mason and Bacsich, 1998, 250).

The literature on computer conferencing provides guidance on the successful design and operation of these systems in an educational context. Cifuentes et al. (1997, 177) identify six design criteria:
a) grading system;
b) grouping;
c) collaboration;
d) relevance;
e) learner control; and
f) technological preparation.

Mason and Bacsich (1998) identify seven key issues:
1) structuring on-line interactions;
2) linking use with assignments;
3) limiting the asynchronicity of the medium;
4) enhancing the social environment;
5) training the tutors;
6) using the medium for feedback; and
7) implementing and supporting a conferencing system.

Other design guides and frameworks are available:

- Understanding and establishment of student motivational incentives (Velayo and McKeachie, 1994);
- Enhancement of knowledge building and quality learning (Nuldén, 1997); and
- Strategies to engage students on-line and prevent ‘lurking’ (Klemm, 1998).

6.3.2 Computer conferencing in management education

The literature reports examples of computer conferencing specifically employed in management education applications. Young and Gilson (1997) note the impact of computer mediated communication (CMC) in both organisational and educational interactions, and many examples of CMC applied in educational contexts. They report on a CMC-based exercise to link full-time, first year business students in Canada with part-time, mature age MBA students in the United States in an exercise designed to highlight aspects of organisational behaviour. They found the exercise successful in meeting their objectives - increasing student communication skills, increasing student awareness of CMC and its impact on groups and organisations and introducing a fun element into learning. Importantly, they note that while the perceived benefit for the MBA students was minimal,

“...it can be argued that the main beneficiaries were the undergraduates...Their euphoria at being about to ‘play in the Majors’...was quite infectious. For them the project played a significant role in exposing them to CMC, thereby providing them with useful career skills and experiences with such technologies. It also introduced them to diversity well beyond their normal classroom experience.” (Young and Gilson, 1997, 69).
This concurs with the earlier observation that the diversity of student backgrounds that come together because of flexible delivery creates the opportunity for mature age students to bring their real-work experience of the engineering workforce and engineering management into the ‘class’ discussion and assist younger, conventional entry students to appreciate the relevance of management studies in engineering. CMC is the means by which the principally off-campus mature age students can participate in the virtual classroom created by the CMC system.

Coincidentally, Bigelow (1999) uses organisational behaviour as the context to provide an overview of the application of on-line technologies, particularly CMC, to management education. He notes a number of differences between face-to-face and on-line media that can be considered as limiting in particular circumstances, including:

- communication richness - non-verbal cues are generally lost;
- communication rate - keyboard-based communication is slower than oral communication;
- student presence - a silent on-line student is virtually invisible;
- team dynamics - arising from slower communication;
- access to information - the bulk of information in libraries is not yet available on-line; and
- self-managed learning - on-line environments are less structured than timetabled classes.

Bigelow (1999) also highlights the positive aspects of on-line interaction:

- communication rate - students have time to read/review what others have written, and interactions may be more thoughtful;
- student presence - students lacking verbal fluency often report being much more confident communicating on-line;
- team dynamics - overbearing/dominating group members lose the ability to use non-verbal message to assert themselves and cannot block the entries of others; and
- self-managed learning - is highly attractive to students in some circumstances.
Bigelow (1999) reviewed the effects (at the level of the class, the small group and the individual) of moving common classroom activities to an on-line medium. While there are some mixed impacts on communication at the level of the class and the group, he reported no impact on most other aspects and, in many cases, positive impacts at the level of the individual. Again, he particularly noted the value of CMC in addressing student diversity:

“The diversity of students can constitute a valuable learning resource...The diversity of a classroom course is constrained by the diversity of the local student population. The diversity of an online course, however, is far less restricted. Students can be enrolled from many geographic regions and cultures, as long as they have Internet access and can communicate in the language of the classroom.” (Bigelow, 1999, 639).

6.3.3 Computer conferencing in an engineering management unit
Again SEB121 Fundamentals of Technology Management was used as the student sample group. The commencing enrolment in this unit at the time of this study was approximately 180 and approximately one third of these students study off-campus.

It was decided to introduce and trial a computer conferencing component into this unit for two principal purposes:
(a) to increase the amount of tutorial-type activity for students, without incurring the same corresponding level of increase in staff resources that would be required for additional class-based tutorials and
(b) to facilitate some form of interaction between off-campus students, who had traditionally been relatively isolated.

Additional possible outcomes that were identified included:
• increased student engagement with the course material;
• additional experience for students in the use of computer and communications technology;
• an opportunity for students to read and reflect on the thoughts and perspectives of their peers; and
• possible interaction between on- and off-campus students, which previously had been virtually non-existent, even though they study identical materials and sit the same examinations.

The framework that was implemented for the computer conferencing component included the following elements identified in Cifuentes et al. (1997):

(a) Grading — students were required to contribute weekly (for seven weeks) to the unit conference by posting their answer to one of three questions on current study topics posted by the author each week; student responses were graded weekly out of 2.0, in 0.5 increments, meaning a total of 14% of the total unit grade was available based on contribution to the conference.

(b) Grouping — no grouping of students into sub-conferences was performed; in the initial trial it was not intended that students would interact heavily on a peer-to-peer basis and that the volume of communication would not be excessive.

(c) Collaboration — the requirement to submit answers to questions did not explicitly require collaboration on the part of the students, though there was an implicit understanding they could read the contributions of other students in the development of their own contributions; while the author read widely, sought advice from colleagues and invited observation of the trial while in progress, there was no collaboration in the implementation and operation of the conferencing system under trial.

(d) Relevance — it was not expected that first year, first semester students would see the immediate relevance of the computer conferencing process to their learning, but the attaching of marks to contribution was seen as a way of emphasising the importance of participation; the content of the conferencing was made more relevant by selecting weekly questions that related directly to the topics being studied at that time.

(e) Learner control — the most appropriate forms of learner control in computer conferencing are still the subject of debate (Cifuentes et al., 1997); in this trial, learner control extended only to the choice between which one of three weekly questions they would answer.

(f) Technological preparation — the results of the previous survey showed a high level of computer proficiency and network access amongst students taking the
class in question; on-campus students were provided with a training session in a campus computer lab, off-campus students were provided with instructions in print on how to access and use the system.

The framework that was implemented for the computer conferencing component also included the following elements identified in Mason and Bacsich (1998):

1) Structuring on-line interactions — conference structure is identified as important for achieving educational outcomes (Mason and Bacsich, 1998, 250); students were provided with a structure in the form of weekly sub-conferences that directly related to the corresponding themes of that week of the semester academic timetable.

2) Linking use with assignments — see (a) above.

3) Limiting the asynchronicity of the medium — the perceived benefit of the asynchronous nature of computer conferencing may, in fact, cause students difficulty in keeping pace with discussion threads and current topics (Mason and Bacsich, 1998, 250); to direct the operation of the conference the weekly question and sub-conference appeared just prior to the corresponding week of the semester and students were encouraged to submit their contribution during that week, this encouragement included a reminder letter should they become tardy by more than two weeks.

4) Enhancing the social environment — for the first week students were simply asked to introduce themselves and a separate, non-formal conference area was provided for on-going, informal and social communication between all conference members.

5) Training the tutors — no ‘tutors’ other than the author were involved in managing the conference; the author had previously attended training sessions in the operation of the conferencing system and had participated as a ‘student’ in an on-line professional development forum using the conferencing system.

6) Using the medium for feedback — the student participation in the conference was closely monitored, the weekly requirement for contribution permitted continuous assessment to be made and immediate feedback to be given to students; students were also able to express their opinions about the exercise (positive and negative) publicly in the conference.
7) Implementing and supporting a conferencing system — all hardware and software infrastructure and required student software was provided centrally by the University, all user documentation and system administration was provided by the author; technical details of the system are documented below.

Other recommendations from the literature that were adopted included:

- expectations with regard to computer conferencing clearly communicated (Velayo and McKeachie, 1994);
- provide simple tasks initially to allow students to explore and practice (Velayo and McKeachie, 1994);
- learner control over submissions — students could edit, amend and update their own previous submissions (Nuldén, 1997);
- source referencing — the conferencing system allowed hyperlinking to external network references and resources from the Internet (Nuldén, 1997);
- instructor controlled submission — the conference administrator had the capability to moderate or censor conference content (Nuldén, 1997); and
- computer platform independence (Nuldén, 1997) — PC and Mac conferencing client programs, as well as a platform independent World Wide Web (Web) interface, were available.

The conferencing system used was the FirstClass system (SoftArc Ltd., 1999); the use of the FirstClass system has been reported widely (Weller and Hopgood, 1997) (Cifuentes et al., 1997) (Vachris and Brendon, 1999). The FirstClass system is based on a client-server architecture; all messages are stored on the server, student access to the conference is by means of a client program. A significant sub-set of the client program functionality is also available by using a Web browser. Hence most students could avoid having to install any new, special purpose software on their computer, should they wish to.

6.3.4 Methodology
The previous survey showed that significant variations in computer usage were correlated to student study mode, that is, on-campus or off-campus. It was hypothesised that similar significant differences would be observed in the computer
conferencing trial (Hypothesis 1). Additionally, it was hypothesised that student attitudes to computers and learning would change following participation in a computer conferencing exercise (Hypothesis 2).

Because all students would be required to participate in identical learning exercises, a pretest-posttest experimental methodology was employed. Students were surveyed during the first week of the academic semester (March 1999) and again during the last week of the academic semester (June 1999). A copy of the initial survey is included in Appendix G - Questionnaire used at start of semester to ascertain computer attitudes and experiences. A copy of the final survey is included in Appendix H - Questionnaire used at end of semester to ascertain computer attitudes and experiences. The initial survey was conducted prior to the introduction of the computer conferencing activity, which commenced in week 5 of the academic semester. For on-campus students the questionnaire was distributed and collected in class; for off-campus students the questionnaire was delivered via post at the appropriate times in the semester, including a reply-paid envelop so off-campus students could return their response at no cost. As required by University research ethics procedures, participation in the survey was anonymous and voluntary.

The initial survey sought information under the following categories:

- demographic information — age; gender; study mode;
- computer/Internet access;
- computer usage; and
- attitudes to computers in education.

The end-of-semester survey sought information under the following categories:

- demographic information;
- computer usage;
- conferencing system usage; and
- attitudes to computers in education.

This data would permit a comparison of results on computer usage with the previous survey, collected from the previous cohort of SEB121 students, as well as permit comparisons of student usage an attitude to computers in the current cohort across the semester of computer usage.
6.3.5 Results - start of semester

6.3.5.1 Response rate
From the total commencing unit enrolment of 179, 122 questionnaires were returned, an overall response rate of 68.2%. The on-campus return rate was 79.1% (102 returns out of 129); the off-campus response rate was 40.0% (20 returns out of 50).

6.3.5.2 Demographic information
The overall proportion of female respondents was 13.1% (14.7% for on-campus students and 5.0% for off-campus students); the overall proportion of male respondents was 86.9% (85.3% on-campus and 95.0% off-campus). The age range of respondents varied widely (17 – 44 years), with an overall mean of 21.1 years and standard deviation of 6.8 (on-campus $M = 18.5$ years, $SD = 2.1$; off-campus $M = 34.4$ years, $SD = 7.2$).

6.3.5.3 Computer/Internet access
Overall, 99.2% of respondents indicated they had access to a computer (99.0% on-campus and 100.0% off-campus). Of those that indicated they had access to a computer, they were further asked to indicate the source of their computer access. Figure 25 shows the indicated source of student computer access for on- and off-campus students.

![Figure 25 - Indicated source of student computer access for on- and off-campus students](image)

On-campus

Off-campus
Overall, 90.2% of respondents indicated they had access to the Internet/Web (89.2% on-campus and 95.0% off-campus). Of those that indicated they had access to the Internet, they were further asked to indicate the source of their access. Figure 26 shows the indicated source of student Internet access for on- and off-campus students.

![Graph showing source of Internet access](image)

**Figure 26 - Indicated source of student Internet access for on- and off-campus students**

**6.3.5.4 Computer usage**
Table 18 gives the percentage of respondents who indicated they used a computer regularly, used e-mail regularly and used the Internet/Web regularly. For those respondents that indicated they used a computer regularly, Table 18 also gives the mean and standard deviation of the reported average hours per week computer usage.

**6.3.5.5 Attitude to computers in education**
Respondents were asked to indicate (yes or no) which of a series of tasks the felt computers were useful for and whether they actually used computers for these tasks.

Table 19 shows the indicated responses as a percentage of total respondents for both on- and off-campus students. For on-campus students, other identified uses and useful applications of computers include personal hobbies, communication and work. For off-campus students, other identified uses and useful applications include work, information and communication.
Table 18 - Reported computer usage for on- and off-campus students, at start of semester

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>On-campus</th>
<th>Off-campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Use a computer regularly</td>
<td>77.0 %</td>
<td>74.3 %</td>
<td>90.0 %</td>
</tr>
<tr>
<td>Mean reported usage</td>
<td>9.1 hrs/week</td>
<td>7.0 hrs/week</td>
<td>19.8 hrs/week</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>9.5</td>
<td>5.7</td>
<td>15.8</td>
</tr>
<tr>
<td>Use e-mail regularly</td>
<td>38.8 %</td>
<td>33.3 %</td>
<td>68.4 %</td>
</tr>
<tr>
<td>Use Internet/Web regularly</td>
<td>52.1 %</td>
<td>45.5 %</td>
<td>88.9 %</td>
</tr>
</tbody>
</table>

Table 19 - Identified uses and useful applications of computers

<table>
<thead>
<tr>
<th></th>
<th>Computers are useful for...</th>
<th>I use computers for...</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>On-campus</td>
<td>Off-campus</td>
</tr>
<tr>
<td>Games</td>
<td>67.6 %</td>
<td>55.0 %</td>
</tr>
<tr>
<td>Internet</td>
<td>91.2 %</td>
<td>95.0 %</td>
</tr>
<tr>
<td>Learning</td>
<td>62.7 %</td>
<td>80.0 %</td>
</tr>
<tr>
<td>Assignments</td>
<td>98.0 %</td>
<td>95.0 %</td>
</tr>
<tr>
<td>Other</td>
<td>10.8 %</td>
<td>40.0 %</td>
</tr>
</tbody>
</table>

Respondents were asked to indicate (yes or no) their agreement with a series of statements relating to the application of computers to teaching and learning. Table 20 shows the indicated responses as a percentage of total respondents for both on- and off-campus students.
Table 20 - Agreement with statements relating to computers in teaching and learning

<table>
<thead>
<tr>
<th>For teaching and learning at university...</th>
<th>On-campus</th>
<th>Off-campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning from computers could never replace classes/lectures</td>
<td>51.0 %</td>
<td>35.0 %</td>
</tr>
<tr>
<td>Computers could never assist my learning</td>
<td>3.9 %</td>
<td>0.0 %</td>
</tr>
<tr>
<td>Computers could assist my learning</td>
<td>79.4 %</td>
<td>90.0 %</td>
</tr>
<tr>
<td>Learning from computers would be better than classes/lectures</td>
<td>5.9 %</td>
<td>20.0 %</td>
</tr>
</tbody>
</table>

6.3.6 Results - end of semester

6.3.6.1 Response rate
From the total end of semester unit enrolment of 132, 81 questionnaires were returned, an overall response rate of 61.4%. The on-campus return rate was 64.0% (64 returns out of 100); the off-campus response rate was 53.1% (17 returns out of 32).

6.3.6.2 Demographic information
Because of the change in student enrolments over the semester, respondent demographic information was collected to ensure comparability between survey groups. The overall, end of semester respondent gender proportions were 90.1% male and 9.9% female. The overall, end of semester mean respondent age was 22.1 years. The overall, end of semester respondent study mode proportions were 79.0% on-campus and 21.0% off-campus.

6.3.6.3 Computer usage
Table 21 gives the mean and standard deviation of the reported average hours per week computer usage at the end of semester for both on- and off-campus students.
Table 21 - Reported computer usage for on- and off-campus students, at end of semester

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>On-campus</th>
<th>Off-campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean reported usage</td>
<td>12.0 hrs/week</td>
<td>9.8 hrs/week</td>
<td>20.4 hrs/week</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>10.8</td>
<td>6.6</td>
<td>17.6</td>
</tr>
</tbody>
</table>

6.3.6.4 Conferencing system usage
Table 22 gives the mean and standard deviation of the reported number of times respondents accessed the FirstClass conferencing system over the semester. Table 22 also gives the reported principal method of accessing the conferencing system, either by means of a Web browser or using the FirstClass client program.

Table 22 - Reported conferencing usage for on- and off-campus students

<table>
<thead>
<tr>
<th></th>
<th>Overall</th>
<th>On-campus</th>
<th>Off-campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean times accessed conference</td>
<td>14.0 times</td>
<td>11.2 times</td>
<td>24.8 times</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>9.4</td>
<td>5.7</td>
<td>12.5</td>
</tr>
<tr>
<td>Main access via Web browser</td>
<td>45.7 %</td>
<td>35.9 %</td>
<td>82.4 %</td>
</tr>
<tr>
<td>Main access via FirstClass client</td>
<td>45.7 %</td>
<td>54.7 %</td>
<td>11.8 %</td>
</tr>
<tr>
<td>Used both Web and FirstClass client</td>
<td>8.6 %</td>
<td>9.4 %</td>
<td>5.9 %</td>
</tr>
</tbody>
</table>

Respondents were asked to indicate their agreement (by selecting one of five points on a Likert-style grading scale) with a series of statements relating to their use of the FirstClass conferencing system. Figure 27 shows the mean and standard deviation of the indicated responses from both on- and off-campus students, based on a grading scale of 1 = strongly disagree, 2 = partially disagree, 3 = unsure, 4 = partially agree and 5 = strongly agree. Table 23 shows the numerical data on which Figure 27 is based, along with an indication of the statistical significance of the difference between on- and off-campus student responses.
A - The FirstClass system was easy to access  
B- The FirstClass system was easy to use  
C - The FirstClass system helped me complete the assignment  
D - I regularly read the messages posted by other students  
E - The assignment helped me to understand the unit material  
F - Using FirstClass would help me in other units I'm studying

Figure 27 - Student perceptions relating to use of the FirstClass conferencing system

Table 23 - Numerical data on which Figure 27 is based, including an indication of significance

<table>
<thead>
<tr>
<th>Statement</th>
<th>On-campus</th>
<th>Off-campus</th>
<th>Significance</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>Mean 4.38</td>
<td>Std. Dev. 0.84</td>
<td>Mean 3.88</td>
</tr>
<tr>
<td>B</td>
<td>Mean 4.47</td>
<td>Std. Dev. 0.71</td>
<td>Mean 3.71</td>
</tr>
<tr>
<td>C</td>
<td>Mean 4.38</td>
<td>Std. Dev. 0.96</td>
<td>Mean 4.53</td>
</tr>
<tr>
<td>D</td>
<td>Mean 3.67</td>
<td>Std. Dev. 1.12</td>
<td>Mean 3.65</td>
</tr>
<tr>
<td>E</td>
<td>Mean 3.66</td>
<td>Std. Dev. 1.03</td>
<td>Mean 3.59</td>
</tr>
<tr>
<td>F</td>
<td>Mean 3.22</td>
<td>Std. Dev. 1.26</td>
<td>Mean 3.71</td>
</tr>
</tbody>
</table>
Overall, 34.6% of respondents indicated they had used the conferencing system to communicate with other students (29.7% on-campus and 52.9% off-campus). In addition to the compulsory usage of the conference required to access and respond to weekly questions, there was also a separate, non-formal conference area provided for informal and social communication between all conference members. Student usage of the informal conference area over the 13 week semester is given in Figure 28. A detailed discussion of the observed usage pattern and other results is included in the Discussion section below.

![Proportion of total messages over weeks](image)

**Figure 28 - Informal student usage of the FirstClass computer conferencing system (week 5A represents an intra-semester break period)**

6.3.6.5 *Attitude to computers in education*
Following the use of the computer conferencing system during the semester, respondents were again asked to indicate (yes or no) their agreement with a series of statements relating to the application of computers to teaching and learning. Table 24 shows the indicated responses as a percentage of total respondents for both on- and off-campus students.

6.3.7 Discussion
6.3.7.1 *Response rate*
Due to enrolment variations in the first semester of university studies, the number of students enrolled in SEB121 can decrease by 15% to 25% over the course of the semester. This, and the fact that students are requested to participate in many surveys at the end of every semester, lead to a decrease in both the number and proportion of voluntary returns for the end of semester questionnaire.
Table 24 - Agreement with statements relating to computers in teaching and learning

<table>
<thead>
<tr>
<th>For teaching and learning at university...</th>
<th>On-campus</th>
<th>Off-campus</th>
</tr>
</thead>
<tbody>
<tr>
<td>Learning from computers could never replace classes/lectures</td>
<td>54.7 %</td>
<td>41.2 %</td>
</tr>
<tr>
<td>Computers could never assist my learning</td>
<td>1.6 %</td>
<td>0.0 %</td>
</tr>
<tr>
<td>Computers could assist my learning</td>
<td>92.2 %</td>
<td>76.5 %</td>
</tr>
<tr>
<td>Learning from computers would be better than classes/lectures</td>
<td>1.6 %</td>
<td>11.8 %</td>
</tr>
</tbody>
</table>

6.3.7.2 Demographic information

The overall commencing female response rate of 13.1% compares closely with the reported commencing female participation rate in Australian engineering undergraduate studies of approximately 14.4% (Department of Education Training and Youth Affairs, 1999). The small absolute number of female respondents suggests caution in making inferences about respondent characteristics based on gender.

The overall commencing age of respondents yielded significantly different distributions between on-campus students ($M = 18.5$ years, $SD = 2.1$) and off-campus students ($M = 34.4$ years, $SD = 7.2$) ($t(19) = -9.73, p < 1 \times 10^{-8}$). The observed differences are as expected and mirror those results obtained in the previous survey.

The overall, end of semester gender proportions were not significantly different to the commencing respondent group ($t(30) = -0.72, p > 0.47$). The overall, end of semester mean respondent age was not significantly different to the mean commencing respondent age ($t(161) = -0.90, p > 0.37$). The overall, end of semester respondent study mode proportions were not significantly different to the commencing respondent group ($t(52) = 0.82, p > 0.41$). These results suggest valid comparisons between the commencing and end of semester survey results can be made.
6.3.7.3 Computer/Internet access
For those respondents indicating they had access to a computer in this study, Figure 25 shows the differences in the source of that access between on- and off-campus students. Off-campus students were largely self-sufficient in computer access (79%), with a small proportion indicating their family as their source of access. By comparison, 60% of on-campus students listed their family, friends or university as the source of their computer access. The distributions of source of computer access were significantly different between on- and off-campus students ($\chi^2(3) = 9.94, p < 0.02$).

For those respondents indicating they had access to the Web, Figure 26 shows the differences in the source of that access between on- and off-campus students. While off-campus students were largely self-sufficient, nearly half of on-campus students were reliant on others (principally the university) for their access to the Internet/Web. The distributions of source of Web access were significantly different between on- and off-campus students ($\chi^2(4) = 18.39, p < 0.0011$). It is interesting to note that, as was found in the previous survey, approximately 10% of on-campus students believe they do not have access to the Internet/Web, when, in fact, all students are provided a computer account through Deakin University that permits access to the Internet. As also noted previously, an induction program in computing for on-campus students could be beneficial.

6.3.7.4 Computer usage
The commencing indicated average hours per week computer usage varied widely (0.5 – 50 hours per week), with significantly different distributions between on-campus students ($M = 7.0$ hours per week, $SD = 5.7$) and off-campus students ($M = 19.8$ hours per week, $SD = 15.8$) ($t(18) = -3.41, p < 0.004$). As at the start of the semester, there were significantly different end of semester distributions of reported average hours per week computer usage between on-campus students ($M = 9.8$ hours per week, $SD = 6.6$) and off-campus students ($M = 20.4$ hours per week, $SD = 17.6$) ($t(17) = -2.36, p < 0.031$). Additionally, there was a significantly higher reported usage at the end of semester compared to the start of semester for on-campus students ($t(120) = -2.77, p < 0.0065$), but no significant change in reported off-campus computer usage ($t(32) = -0.046, p > 0.96$).
At the commencement of the semester, computer usage by off-campus students was, on average, nearly three times greater than on-campus students. In the previous survey an apparent link was found between off-campus students (who are predominantly mature aged) and occupational computer usage, leading to much higher rates of computer usage than their on-campus counterparts. It can be seen on-campus students have increased their usage of computer, on average, by 40% over the duration of the first semester of their studies. This is likely to be due to multiple factors, including:

- greater access to computers in on-campus university computing laboratories;
- general requirements to use computers in their engineering studies; and
- the particular requirement in the study unit SEB121 to regularly access and contribute to the computer conference.

Even though 99.0% of on-campus students reported having access to a computer, only 74.3% designated themselves as regular computer users; for on-campus students, access to computers does not automatically translate to regular usage. All off-campus students reported having access to a computer and 90.0% designated themselves as regular computer users. The rate of indicated regular computer usage was moderately different between on- and off-campus students ($t(36) = -1.94, p < 0.06$).

In both cases, the proportion of off-campus students indicating themselves as regular users of e-mail and of the Internet/Web was approximately twice that of on-campus students. The regular use of e-mail was significantly different between the two student groups ($t(25) = -3.01, p < 0.006$). The much higher usage rate for off-campus students may be due to their adoption of electronic communication as a means of overcoming distance barriers to communication in their studies and/or their prior exposure to e-mail as a means of corporate communication. Overall, slightly more than half of the respondents indicated they were regular users of the Internet/Web. As for e-mail usage, there was a significant difference between the reported regular
usage of the Internet/Web between on- and off-campus students ($t(34) = -4.86, p < 0.00003$).

The differing indicated sources of Internet/Web access may explain the differing usage patterns. 95% of off-campus students have Internet access at home, making it potentially easier for them to access e-mail and the Web at a time of their choosing; though access from home would normally involve a cost to the student in access charges from a commercial Internet service provider (ISP). Conversely, only slightly more than half on-campus students reported Internet access at home; with nearly half reporting their place of access was the University.

Both on- and off-campus students reported a high proportion of access to the Web (90.2% overall), so it is not a lack of access that make on-campus students relatively low users of the Web. As noted in the previous survey, it seems clear off-campus students will be in the best position to benefit from the provision of Internet-based resources in teaching and learning.

6.3.7.5 Conferencing system usage
The reported number of times students accessed the FirstClass conference had a wide range (3-60 times), with a significantly different distribution between on- and off-campus students ($t(17) = -4.23, p < 0.0006$). On average, off-campus students accessed the conferencing system more than twice as many times as on-campus students did. Responding only once per week for the seven compulsory weekly questions means a student could fully complete the conference-based assignment tasks with a minimum of seven accesses. In practice, the weekly conference areas were left open for contributions beyond that nominal week of the semester, meaning tardy students could access the system infrequently and make several weeks’ worth of contributions at once.

Overall, equal numbers of students reported using the Web interface and the FirstClass client program as their main method of accessing the conference, with less than 10% of students indicating they regularly used both methods of access. The main method of access was significantly different between on- and off-campus students; more than 80% of off-campus students identifying the Web as their main
mode of access and more than 50% of on-campus students identifying the FirstClass client program as their main mode of access. Off-campus students were encouraged to use the Web interface to FirstClass, as all required conference functions were available by using a Web browser and most off-campus students already have a Web browser installed on their computer, avoiding the need to distribute, install, configure and become familiar with a new software package. On-campus students were encouraged to use the FirstClass client program available to them in the university computer laboratories, and even though tutorial sessions were provided on the use of the client program, a surprising proportion of on-campus students (35.9%) identified the Web as their main mode of access to the conference. This may reflect a section of on-campus students accessing the conference system from home using a Web browser.

Figure 27 and Table 23 summarise student perceptions of the FirstClass conferencing system. Overall, there was moderate agreement (partially agree or greater) that:

- the FirstClass system was easy to access;
- the FirstClass system was easy to use; and
- the FirstClass system helped students complete the conferencing assignment.

Overall, there was less strong agreement (between unsure and partially agree) that:

- students regularly read messages posted by other students;
- the assignment helped students understand the unit material; and
- FirstClass conferencing would help with other units studied by the students.

Some moderate statistical differences (see Table 23) were observed between on- and off-campus students; off-campus students were less likely to agree the system was easy to access and easy to use, but were more likely to agree FirstClass would help them in other units they were studying. These results probably reflect:

- the general difficulties off-campus students face in establishing dial-up, modem-based network connections (on-campus students have access to networked computing laboratories);
- most off-campus students used the Web interface to FirstClass; and while it provides most features of the client program, the limitations of the Web interface make some functions more cumbersome to use; and
most off-campus students perceive a benefit in any avenue that increases their opportunity to interact with academic staff and other students to create a sense of community and shared experience in their learning.

While both student groups were equivocal in their support of the statement ‘I regularly read the messages posted by other students’, off-campus students (more than half) were more likely than on-campus students (less than 30%) to report using the conferencing system to communicate with other students ($t(23) = 1.74, p < 0.1$). This suggests many off-campus students found the conference to be a useful medium for communication with their student peers.

Figure 28 shows the proportion of total messages from the informal conference area that was contributed during each week of the academic semester over which the conferencing trial was run. The following points should be noted:

- on-campus students were not formally introduced to the operation of the FirstClass conferencing system until week 5 of the semester;
- this chart is exclusive of the message volumes generated by the compulsory, assessed conferencing contributions;
- week 5A represents an intra-semester lecture break that is not counted in the nominal 13 week academic semester; and
- other assessable assignment tasks were due for submission in week 8 and week 12/13.

Use of the conference space prior to week 5A/6 is almost exclusively due to off-campus students. Following early problems in sending instructions on the use of the conference to off-campus students, informal contributions built steadily from week 3 as students got themselves on-line. Informal contributions declined during the intra-semester break and then varied over the remainder of the semester. During week 8, where an assessment task was due for the unit SEB121, informal contributions dropped to zero. Another major assessment task was due in week 12/13, perhaps being the cause of low informal contributions in week 12. Week 13 is traditionally the revision/exam preparation week for the semester, with exams following shortly after; no informal contributions were recorded in week 13, or any time after week 13.
Non-compulsory, informal conference contributions exhibited early interest and enthusiasm amongst off-campus students, but appear to be highly dependent on external factors that affect the student’s capacity to devote time to extra-curricula activities.

6.3.7.6 **Attitude to computers in education**
There were no significant differences between the tasks identified by on- and off-campus students that computers are useful for, except off-campus students were moderately more likely (80.0%) than on-campus students (62.7%) to indicate computers were useful for learning \((t(30) = -1.7, p < 0.1)\). However, when it came to the reported tasks that students *actually* used computers for, there were some significant differences. On-campus students were more than three times more likely \((65.7\%)\) to report using computers for playing games \((t(30) = -4.52, p < 0.00001)\), and off-campus students were significantly more likely to report using computers for learning \((75.0\%)\) than on-campus students \((44.1\%)\) \((t(29) = -2.84, p < 0.009)\). Off-campus students were slightly more likely to report using computers to access the Internet, and high proportions of both on- and off-campus students \((95\%–99\%)\) reported using computers to complete study assignments. On-campus students in this unit are principally adolescents, and the high usage of computer games by adolescents is noted in the literature (Griffiths and Hunt, 1998). Off-campus/mature age students seem to have already had experience in using computers for education/learning, though the source of this is unknown. Both groups of students are familiar with the concept of using the computer in completing assignments. In the previous survey of students taking this class the most commonly reported computer application amongst both student groups was a Wordprocessor, suggesting that one of the principal uses of computers for students was as an ‘electronic typewriter’ for the preparation of written work.

At the start of the semester no significant difference was found between on- and off-campus student agreement with statements in Table 20 relating to computers in teaching and learning. However, off-campus students were moderately less likely to agree that ‘computers could never assist their learning’ \((t(101) = -2.04, p < 0.044)\), though the level of agreement was low for both students groups. That is, most students felt computers could assist their learning and off-campus student were more
likely to hold this opinion. At the end of semester no significant difference was found between on- and off-campus student agreement with statements in Table 24 relating to computers in teaching and learning.

Examining the summary results presented in Table 20 and Table 24 appears to show some evidence for changes in attitude to computers in teaching and learning over the semester, but statistical analysis of the source data reveals that the changes are limited. The increase in agreement with the statement ‘computers could assist my learning’ by on-campus students from 79.4% to 92.2% is moderately significant ($t(163) = -2.45, p < 0.016$), indicating that experience in using computers in their learning has improved the attitude of on-campus students. A similar sized fall in agreement with this statement by off-campus students, from 90.0% to 76.5% is less significant ($t(28) = 1.10, p > 0.28$) because of the smaller number of off-campus students. The decrease in agreement with the statement ‘learning from computers would be better than classes/lectures’ by on-campus students from 5.9% to 1.6% is moderately significant ($t(159) = -1.54, p < 0.125$), indicating that the dual experience of the reality of university studies and of actually using computers in learning has reduced the small number of on-campus students who believed learning from computers would be the best mode of education. A similar fall in agreement with this statement by off-campus students, from 20.0% to 11.8% is less significant ($t(34) = -0.69, p > 0.49$) because of the smaller number of off-campus students. Taken collectively, these results suggest that a semester of experience in using a computer conferencing system as an assessable component of studies has increased an initial moderate level of support for computers in teaching and learning held by on-campus students and tempered an initial high level of support for computers in teaching and learning held by off-campus students.

6.3.7.7 General

Hypothesis 1, that significant variations in computer usage would be correlated to student study mode was confirmed. The following significant differences between on- and off-campus students were noted:

- the source of computer access;
- the source of Internet/Web access;
- the indicated average hours per week computer usage;
• the regular use of e-mail;
• the regular use of the Internet/Web;
• the number of times the computer conference system was accessed;
• the reported use of computers for playing games; and
• the reported use of computers for teaching/learning.

The following moderate differences between on- and off-campus students were noted:
• the regular use of computers;
• agreement the computer conferencing system was easy to access;
• agreement the computer conferencing system was easy to use;
• agreement the computer conferencing system would help them in other units;
• the reported use of the conferencing system to communicate with other students;
• agreement computers were useful for teaching/learning; and
• agreement computers could never assist teaching/learning.

Hypothesis 2, that student attitudes to computers and learning would change following participation in a computer conferencing exercise, was only partially confirmed. At the end of the semester, on-campus students were significantly more likely to agree computers could assist their learning and off-campus students were moderately less likely to agree learning from computers would be better than classes/lectures. This suggests that prior to using a computer conferencing system in their university studies, on-campus students may have been unduly pessimistic, and off-campus students may have been overly optimistic, about the value of computers in teaching and learning. Off-campus students may also have experienced technological difficulties in remotely accessing the conferencing system.

The evidence suggests that both on- and off-campus students derived value from the computer conferencing system and that the system is an appropriate adjunct to engineering management studies; but that the differences between the two student groups do influence both their capacity to use computer-based systems and their perceptions of the use of computers in education. When designing a CMC system, as
with any other aspect of flexible delivery, the characteristics of the various student groups who will use the system need to be considered. While off-campus students appear well placed to take advantage of the enhanced learning environment offered by the CMC system, on-campus students may require orientation at the commencement of their studies to be able to most effectively use the computer-based resources on offer to them.
7 - Discussion

7.1 Introduction

This chapter considers the work on the content and delivery of undergraduate engineering management education presented thus far and draws out the critical issues in light of the project framework given in Table 1, as well as examining the implications of these findings.

7.2 Engineering management and engineering management education

The questions remain. What is engineering management? What body of knowledge and skills does it require? At first sight these questions appear easy to answer. The former ‘simply’ requires an appreciation of the disciplines of engineering and management, and the latter ‘naturally’ arise from an understanding of the former. Under closer examination the appearance of simplicity collapses.

The nature of engineering and the engineering profession is entering a period of fundamental change. As evidenced by the rapidly increasing array of engineering disciplines in which a student can study, the engineering knowledge base is exploding. Traditional disciplines are fragmenting into new specialisations as these areas develop their own bodies of knowledge. The concept of professionalism is under challenge and change. Traditionally, ‘professionalism’ has conferred status and reward for the professional, in return for the ethical application of specialised skills and knowledge for the general good of society. Because many professional groups enjoy legal status as the sole supplier of particular services and as the regulator of their own membership, free market and competition ideologies view professionalism as a device for the restraint of trade, the defeat of labour substitution and the maintenance of exclusivity of membership. In Australia, many professions have been challenged by society over these issues, including engineering (Blandy and Richardson, 1982) (Bureau of Labour Market Research, 1985) and architecture (Boshier, 2000, 68). The ‘social contract’ between the professions and society has been broken (Longstaff, 1999) and improved ‘competition’ in engineering has led to a decline in IEAust membership and a more individualistic and itterate approach to engineering practice. To this can be added the emerging challenges of the
globalisation of engineering practice and the growing influence of information technology, and from this it is clear that the practice of engineering will continue to undergo transformation.

An understanding of management is no more straightforward than an understanding of engineering. Hope and Hope (1997) synthesise the works of many recent management ‘gurus’ to identify the 10 key management issues as:


But these have been important management issues for many years now and are likely to continue to be critical. The difference is really that the context in which management operates has changed, will continue to change and the rate of that change will continue to accelerate. Vokurka and McCaskey (2001) identify the following elements contributing to change:

- intensifying competition;
- proliferation of products;
- shortening product life cycles;
- rapidly advancing technologies;
- IT used as a competitive weapon;
- globalisation - competitors are no longer local or national only;
- increasing customer requirements - they want it “free, now and perfect”;
- electronic commerce; and
- better access to information.

Arguably, one omission from this list of elements is environmental/sustainability imperatives. A matrix of management issues versus elements of change could be derived to help identify the impacts of change on management.

Change also provides a link between engineering and management by continuing to drive the advancement of technology (and hence the creation of new engineering
knowledge) and the context in which managers operate. At this point we have returned to Heraclitus’ quotation about change, “Nothing endures but change”. Add to this the changes occurring in higher education, and engineering management education can truly be seen as a moving target. Engineering management is about the management of engineering, but as has been shown, what this actually entails is context dependent and this will evolve over time as the underlying technologies and management views change, and as the work roles of the engineer develop and change.

Hughes (1998) indicates how difficult it is to identify a body of knowledge appropriate to all managers, as their work roles and contexts are so variable and that their skill requirements change over time. In this environment the futility of rigidly prescribing the content of an engineering management course in detail is exposed. What engineering managers do and how they do it will change over time. The only practical approach is to identify the required graduate attributes and outcomes (including those that will be required in the near future) and adjust the course content, delivery methods and assessment to ensure that these outcomes are achieved. By definition, this is a dynamic process that must periodically be repeated to effectively address change.

The research presented in this thesis identifies a framework of engineering management skill types and ranks these according to perceived importance by practising engineers, engineering managers and engineering academics. Using the various management skills/competencies identified from the surveys along with those presented in the literature, a ranked classification can be proposed as shown in Table 25.

The list cannot claim to be exhaustive, the most that can be said about the framework is that it documents those types of engineering management skills important for practice in Australia in the present. No claim can be made about the sub-ranking of the importance of the skills listed within each of the three broad categories. Any individual practising engineer might select as important a subset of those management skills presented, to which they might add other items important to them
Table 25 - Framework of ranked classified engineering management skills

<table>
<thead>
<tr>
<th>1. Generic professional practice skills</th>
<th>2. Generic management skills and Specialised technical discipline management skills:</th>
</tr>
</thead>
<tbody>
<tr>
<td>• Written &amp; oral communication skills</td>
<td>• Human resource management</td>
</tr>
<tr>
<td>• Project planning and management</td>
<td>• Business strategies</td>
</tr>
<tr>
<td>• Supervision and leadership</td>
<td>• Negotiation/conflict resolution</td>
</tr>
<tr>
<td>• Teamwork</td>
<td>• Organisational behaviour</td>
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<td></td>
<td>• Quality management</td>
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<td></td>
<td>• Operations management</td>
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<td></td>
<td>• Industrial relations</td>
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<td></td>
<td>• Networking</td>
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<td></td>
<td>• R&amp;D/design management</td>
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<td></td>
<td>• System approach</td>
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<td></td>
<td>• Environmental management</td>
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<tr>
<td></td>
<td>• Logistics/supply management</td>
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<tr>
<td></td>
<td>• Occupational health &amp; safety</td>
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<td></td>
<td>• Contract administration</td>
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<tr>
<td></td>
<td>• Personal/time management</td>
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<tr>
<td></td>
<td>• Risk management</td>
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<tr>
<td></td>
<td>• Maintenance management</td>
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<tr>
<td></td>
<td>• Change management</td>
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<tr>
<td></td>
<td>• Professional ethics/social aspects</td>
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<td></td>
<td>• Innovation/creativity</td>
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<td></td>
<td>• International business</td>
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<td></td>
<td>• Decision making</td>
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<tr>
<td></td>
<td>• Dealing with customers</td>
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<td></td>
<td>• Information technology</td>
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<tr>
<td></td>
<td>• Public relations</td>
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<tr>
<td></td>
<td>• Strategic management</td>
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<tr>
<td></td>
<td>• Motivation/psychology/behaviour</td>
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<td></td>
<td>• Work/time study</td>
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<td></td>
<td>• Performance evaluation/management</td>
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<td></td>
<td></td>
</tr>
<tr>
<td>3. Theoretical skills and Skills related to other professional disciplines:</td>
<td></td>
</tr>
<tr>
<td>• Theories of management</td>
<td>• Ergonomics</td>
</tr>
<tr>
<td>• Economics</td>
<td>• Management science</td>
</tr>
<tr>
<td>• Accounting &amp; finance</td>
<td>• Marketing</td>
</tr>
<tr>
<td>• Legal/law</td>
<td>• Forecasting</td>
</tr>
<tr>
<td>• Information management</td>
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</table>

in their particular circumstances and/or they might re-classify particular skills depending on their area of practice.

Many of these same skill types have been important in the past and are likely to remain important for the foreseeable future, although the nature of the skill is likely to change over time. For example, in times past, effective communication skills for an engineer may have encompassed dictating correspondence, manually sketching a design drawing and delivering directions to a work team. More recently effective
communication skills might include wordprocessing your own written correspondence, sending e-mails instead of memos, use of a CAD package to produce working drawings and delivering an oral presentation with supporting computer-based slides to potential customers. In the future the important communication skills might incorporate speaking in a steady consistent tone into a voice-to-text device, skilfully manipulating a ‘datastick’ to add annotations to a 3D rendered model of a new plant still under design inside a virtual environment and knowing when to pause to allow for communication link delays in a five-way video conference link-up of team members located on three different continents.

The often quoted distinction between training and education is that, ‘training provides specific knowledge and skills required for current tasks, while education provides knowledge and skills for the unknown tasks that will be faced in the future’. If education is to effectively equip students to tackle the tasks of the future, then thought must be given to the future of the discipline(s) under study. As well as providing students with immediately applicable competencies, education should look to equip graduates with the skills that will serve them beyond graduation and into their professional careers. The literature provides some guidance as to the emerging management skills that engineers will require, and this issue is examined in the remainder of this section. These skills may at some time in the future assume the importance of ‘generic professional practice skills’ that will be important for all engineers, regardless of discipline or organisational rank.

The 1994 Green Report of the American Society for Engineering Education identified the following curricula items as essential for the preparation of students for the broadened world of engineering practice:

“

- team skills, including collaborative, active learning;
- communication skills;
- leadership;
- a systems perspective;
• an understanding and appreciation of the diversity of students, faculty and staff;
• an appreciation of different cultures and business practices, and the understanding that the practice of engineering is now global;
• integration of knowledge throughout the curriculum;
• a multi-disciplinary perspective;
• a commitment to quality, timeliness and continuous improvement;
• undergraduate research and engineering work experience;
• understanding of the societal, economic and environmental impacts of engineering decisions; and ethics.” (American Society for Engineering Education, 1994, Reshaping the Curriculum, ¶ 6).

In a keynote presentation to the 6th AAEE conference, that was based on a position paper for the 1996 Johnson review of engineering education in Australia, Clyde (1995) identified the following emerging factors influencing engineering:
• move to a knowledge based society where knowledge is the most important commodity;
• new knowledge based industries that do not require large capital investments and lead to increases in world GDP even as energy and natural resource markets are depressed;
• computer technology that permits complex tasks to be executed in the background of processes, products and projects;
• move to global economies with an emphasis on free trade;
• free trade implies internationalisation of standards;
• new economic theories that consider that technological change responds to prices and profits;
• employment growth in small to medium enterprises (SMEs), and government employment has decreased dramatically;
• very long range economic cycles driven by infrastructure replacement; and
• asset management.
Following from these issues, Clyde (1995) identified the following items to be addressed by Australian engineering education programs of the future:

- abandonment of a traditional liberal education in student preparation;
- changes in the scientific preparation of students;
- the need to provide general introductory years for all engineering students to restore cross-disciplinary awareness;
- inculcation of a culture that recognises that engineers must accept autonomous responsibility at an early stage and exhibit leadership;
- inclusion of sustainability and quality principles in all engineering;
- the legal, social and business conventions, laws, practices and expectations of society;
- the economic facts of competition, nationally and internationally and the need to be innovative;
- the reduction in opportunities for industry to provide professional formation of new graduates in light of the shift in employment from government to small private employers; and
- dealing with risk, litigation, industrial confrontation, competition for professional work on price, etc.

In 1997 the International Federation of Consulting Engineers identified the following global trends in consulting engineering:

“...consultants need to
- embrace a broader array of talent
- be client-focused providing services the client needs
- assume a greater proportion of the risk in projects
- become competitive players in financing
- become dealmakers themselves.” (Georg, 1997, 1).

Williams (1998) reports on a technological foresight exercise undertaken by the Australian Science, Technology and Engineering Council (ASTEC) to identify key issues, key forces of change and critical technology areas related to achieving a
‘preferred future’ for Australia in 2020. The outcomes were identified as a basis for action in engineering education and were summarised as:

“Key Issues

- the need for innovation and entrepreneurship;
- the need for a technologically literate society;
- the need to capture opportunities for globalisation;
- the need to sustain our natural environment;
- the need for continuous improvement in community well-being;
- the need to build a forward looking S&T system.

Key Forces of Change

- global integration;
- applying information and communications technologies;
- environmental sustainability;
- advances in biological technologies.

Critical Technology Areas

- environment, including energy;
- transportation;
- information and communications technology and electronics;
- genetics and biotechnology;
- precision manufacturing;
- new materials.” (Williams, 1998, 8).

A key driver of change in engineering education is globalisation and the associated internationalisation of engineering practice. Many regional arrangements permit mutual recognition of engineering qualifications and hence the trans-border movement of qualified practising engineers. Examples of these arrangements include:

- a North American Free Trade Agreement (NAFTA) initiated negotiation between the United States, Canada and Mexico that resulted in a Mutual Recognition
Document to permit engineers licensed in any of the three countries to practice in the other two (Jones, 1999);

- an Asia Pacific Economic Cooperation (APEC) group sponsored register that permits qualified professional engineers from APEC member countries to practice in other member countries (Boshier, 2001); and

- the ‘Washington Accord’, an agreement for mutual recognition of undergraduate engineering qualifications between eight mainly western, non-European nations has been joined by the Federation of European National Engineering Associations and the Japan Consulting Engineers Association to pursue the possibility of international mutual recognition of right to practice (Jones, 1999).

An inevitable outcome of the drive towards international mutual recognition of engineering qualifications is the harmonisation of educational requirements and standards at the undergraduate level, and there has been some progress in Western Europe on this matter. While ‘global engineering education’ may still be some way off, it is clear that the technology aspects of engineering education transfer much more readily across international boundaries than do the ‘non-technical’ (read management) components. It is in the non-technical areas of the curriculum where the international/global interfaces will require the most effort to make them work.

The 1995 Karpin Report concluded that management skills underpin the living standards and employment prospects of all Australians and that although Australians enjoy a relatively high standard of living, our capacity to remain internationally competitive has been in decline for some time:

“Australian management must improve significantly in the next decade if enterprises expect to even meet today’s world best practice standards.” (Karpin, 1995, xiv).

The report noted an apparent lack of entrepreneurial skills in Australian managers, compared to some of our trading partners and competitors, and a negativity associated with the term entrepreneur, not assisted by the spectacular business failures of some Australian ‘entrepreneurs’ during the 1980s. The first and
foundation recommendation of the report was the development of an enterprising culture in the national systems of education, as well as in the community generally.

“Managers and employees, in small, medium and large enterprises, need to be more enterprising in seizing the opportunities presented to us by the Asia-Pacific Century. Creating a positive enterprise culture is also by far the biggest challenge faced by our nation - involving as it does a change in the values inculcated in the education system, in the workforce and in firms.” (Karpin, 1995, xix).

The 2000 report of Australia’s Chief Scientist, The Chance to Change, identified that the only way for Australia to maintain a prosperous society was through innovation, and that innovation is underpinned by science, technology and engineering. The report acknowledges that innovation is much more than simply good ideas and technical capability:

“Innovation is much more than invention or R&D. It encompasses all activities encouraging the commercialisation and utilisation of new technologies—scientific, technological, organisational, financial and business. It is now widely accepted that innovation is the key to future prosperity.” (Batterham, 2000, 15).

Science, engineering and technology are the drivers of innovation and national prosperity. The enabling factors for innovation to occur and economic benefits to flow from scientific and technological endeavour are entrepreneurship, business and management skills. It has been said that Australia’s future engineering graduates need to be employers, rather than employees - job makers, rather than job takers. That is, we need graduates who can be entrepreneurs and who will create the employment opportunities for individuals and wealth for the nation. Engineering education has to take up this challenge and provide the broader knowledge and skills required beyond technical excellence. Summarising the previous examination of the literature, Table 26 identifies the required engineering management skills of the future.
Table 26 - Engineering management skills of the future

<table>
<thead>
<tr>
<th>System perspective of complexity</th>
<th>Internationalisation / cultural understanding</th>
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<tr>
<td>Globalisation (of trade and competition)</td>
<td>Multi-disciplinary aspects of engineering</td>
</tr>
<tr>
<td>Societal impacts of technology</td>
<td>Knowledge as a (valuable) commodity</td>
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<tr>
<td>Information &amp; communications technologies</td>
<td>SMEs where employment growth occurs</td>
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<tr>
<td>Asset and infrastructure management</td>
<td>Responsibility, authority &amp; leadership</td>
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<tr>
<td>Legal, social and business aspects</td>
<td>Competition and economics</td>
</tr>
<tr>
<td>Innovation and creativity</td>
<td>Entrepreneurship and initiation of projects</td>
</tr>
<tr>
<td>Risk and litigation</td>
<td>Sustainability/environment/lifestyle</td>
</tr>
<tr>
<td>Ethical engineering practice</td>
<td>Globalisation of engineering practice</td>
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Clearly, not all of the future issues identified above are the exclusive domain of engineering management education, and some are already presently included in current engineering curricula. But, many are beyond the scope of the science/technology-focussed elements of a traditional engineering course. Unless traditional engineering education demarcations are removed and technology elements are taught in the broader context of engineering practice, then the burden on ‘engineering management’ studies looks set to increase. It could be suggested that in a perfect world where engineering education was based on contextually integrated studies of the science and application of engineering, there would be no need for separate engineering management studies. Whether it is as separate units of study or integrated into general engineering studies, the next two sections consider the flexible delivery of engineering management education.

7.3 Flexible delivery of engineering education

Chapter 5 identified the lack of an agreed definition as to what constitutes flexible delivery (Hodgson, 1993), but noted the inexorable trend toward on-line delivery being synonymous with flexible delivery (Ryan, 1998). Educational institutions that once had a competitive advantage based on expertise in print-based (or other modes of) delivery are likely to find this advantage eroded as the basic flexible delivery medium moves to the Web, where expertise in other delivery mediums does not necessarily translate into a strategic advantage over newer competitors operating in a common on-line environment. A fundamental purpose of the flexible delivery of education is to employ alternate methodologies to provide off-campus students with
access to course materials and learning experiences. While this may incorporate some tangible, physical materials, it is principally about the transfer of information and opportunities for communication/collaboration. Print materials have traditionally been the mainstay of various forms of flexible delivery. However, on-line channels offer the opportunity to transfer information and communications at a reduced cost and time delay than the print medium. In certain locations, flexible delivery may continue to mean traditional off-campus delivery media, but in the context of this project, flexible delivery will more and more mean on-line delivery of teaching and learning.

While increasing Internet access, increasing student demand for on-line learning, changes in the copyright law to facilitate on-line delivery of third party content, emerging competition (both locally and internationally) in on-line education delivery markets and evidence that on-line delivery will not be a barrier to access for off-campus engineering students may all mean that the medium of flexible delivery will be the Internet/Web, virtually all of the considerations relating to conventional flexible delivery identified in Chapter 5 will still apply.

Regardless of the medium of delivery, in a flexible delivery program there will still inherently be a diverse student body; this may span 18 year old students directly from secondary school to 30 year old tradespeople looking to upgrade vocational qualifications to middle aged people seeking a change in career direction, all with differing needs, motivations and expectations. If the course material is developed in a modular fashion, there is still a need to ensure integration of learning across the course and to carefully control the sequence of studies. The incorporation of mature age students into the program still requires the issue of recognition of prior learning to be addressed. Course materials still have to be produced and stored for future delivery, rather than created on the spot in the classroom. The production of course materials will still be expensive and time consuming, and the financial viability of such developments still need to be considered. Practical/laboratory work elements of the course still need to be addressed for students located remotely from the institution.
In addition to the considerations that apply to print-based flexible delivery, some ‘new’ considerations are apparent. Course material developed and delivered on-line can be updated at any time, in theory leading to study materials that can more quickly incorporate the latest developments. In practice, changes to course materials during a teaching period are likely to lead to student confusion; if multiple revisions are made, different groups of students may find themselves studying different basic course materials. As for print-based course materials, instructional design and presentation of information plays a key role in producing effective on-line study materials.

However, the computer screen poses different visual challenges to the instructional designer. Complicating this is that many students are likely to print off at least parts of an on-line program, so they have the convenience to study when not on-line. No matter what the medium, course designers still need to ensure that students will develop the desired/required generic and discipline-specific skills and knowledge by undertaking the course. Availability and reliability of on-line infrastructure is a key factor in the success of on-line studies. This issue is made more complex by the fact that the infrastructure is widely distributed; various parts of the University will be responsible for the origination of the material, it will be transported over public and private communications networks and will be displayed and stored on a wide array of student computer equipment. A failure in any part of the system will cause disruptions to the study of varying numbers of students. In reality, not that much is actually new under the sun. These ‘on-line issues’ are really analogous to issues that arise from flexible delivery, no matter what the transmission/communication medium.

A key issue often identified in the move to on-line delivery is staff development. Once again, this issue is not unique to on-line delivery, as the design, development and delivery of flexible learning, regardless of the medium, require new skills beyond classroom teaching. While it is not unique to on-line delivery, it is none-the-less critical. Staff participating in the delivery of such flexible programs require access to the appropriate training and development to provide them with the new skills they require to contribute effectively. The 1999 National Survey of Information Technology in Higher Education in the United States found that, “Assisting faculty efforts ‘to integrate technology into instruction’ remains the single most important
information technology (IT) challenge…” (The Campus Computing Project, 1999, 1).
Another important and closely related issue is that as well as appropriate training, staff also require access to a reward scheme that recognises and values the new type of work required to develop and deliver flexible mode teaching and learning materials. Padget and Conceição-Runlee (2000) note on the challenges of developing a staff development program on technology:

“The most consistent recommendation regarding a faculty development program on technology relates to institutional structure and the integration of the program with the institution’s infrastructure of rewards, workload expectations and incentives...Promotion and tenure expectations which do not reward technical creativity can inhibit faculty involvement in technology training. Competing demands on faculty members’ time present very real obstacles to their participation in faculty development programs.” (Padgett and Conceição-Runlee, 2000, 331).

They also note that the early adopters of on-line technology often end up as unpaid trainers for other staff. Tilson et al. (2000) reporting on the developmental issues for on-line programs identify that:

“A developmental issue that remains unresolved is faculty rewards and ownership. In most institutions, rewards such as reassignment time, sabbatical leave, promotions or salary increases are greater for textbook publishing or course development than for developing an online course. As a general rule, it seems that most institutions are happy to see online offerings but there is little monetary or developmental support for the extra effort.” (Tilson et al., 2000, 169).

Staff development issues don’t just relate to existing staff. In engineering education in Australia, it would be unusual to find commencing staff with any formal studies in education and training, let alone flexible delivery and on-line educational technologies. In the near future, the demand for on-line studies will mean that all educators are likely to be involved in flexible delivery. Preparing someone for a teaching role now needs to incorporate technology-mediated delivery, as all
education will be increasingly ‘technology enhanced’, even if it is ‘only’ classroom teaching.

For engineering education in Australia, the IEAust is an influential policy setting body. In 1976 the IEAust developed policies on ‘professional engineering courses utilising external study programs’ that permitted, “institutions to make available external courses for students who cannot attend full-time on campus”. Up until 1991 the policy required students to attend at least the final two semesters on campus. In 1991, in recognition of the advancements in educational technology, the on-campus attendance requirement was waived, but there remained an onerous requirement to document the attainment of a wide range of skills and experience by off-campus students - far in excess of the requirements for courses having on-campus students only. The revised accreditation requirements flowing from the Johnson review of engineering education provided a single set of requirements for all undergraduate engineering programs, regardless of the educational methodologies employed. In 2000 the general course accreditation requirements were supplemented with an Interim Policy on Accreditation of Programs Offered in Distance Mode (Institution of Engineers Australia, 2000), which, while not altering the fundamental requirements for course accreditation nor affecting the standing or parity of off-campus study, did identify twelve points that will be particularly examined in the accreditation of off-campus undergraduate engineering programs. Flexible delivery of engineering education in Australia enjoys, at least theoretically, the same standing as courses delivered on-campus; this is achieved by having to satisfy the same basic accreditation requirements as all other Australian engineering programs.

As noted in Chapter 5, engineers are significant users of flexible learning, which now means on-line learning:

“E-learning, especially for engineers and executives in technology industries, has emerged as one of the fastest-moving trends in higher education...As any engineer knows, there is tremendous pressure to keep pace with the latest technology and the newest ways of doing business...Yet few engineers have the luxury of attending classes on well-groomed college campuses.” (Ubell, 2000, 60).
While undergraduate engineering courses offered completely on-line do exist in the United States, at present on-line-only engineering courses are principally reserved for postgraduate studies (Wallace, 1999). This is also the case in Australia, but both conventional and flexible engineering programs can derive significant benefit from incorporating on-line components. As the demand for on-line studies continues, it is likely that the on-line component of all types of educational programs will increase.

7.4 Flexible/on-line delivery of engineering management education

It was argued in Chapter 6 that many aspects of management studies are suited to flexible and/or on-line delivery. While many areas of study in engineering courses require laboratory practical work that will require innovative approaches to be effectively delivered on-line, management studies normally do not have ‘lab work’ per se; the practical requirement in management studies would normally involve research and investigation of case studies and other information, discussion and group collaboration - all of which are facilitated by on-line technologies, particularly for flexible mode students studying remotely from the campus. Schreuder and Kuysters (1999) note that interpersonal skills require face-to-face contact, but general business skills can be delivered with information and communication technology:

“Leadership, empowerment, coaching and other interpersonal competencies will always need group training methods. However, finance, logistics, strategy or marketing will be increasingly developed with the use of less personal learning methods, individually and/or at a distance.” (Schreuder and Kuysters, 1999, 108).

For flexible delivery of engineering management studies, regardless of whether that means print-based delivery, on-line enhanced print material, or completely on-line delivery, we must be able to ensure that students have had an appropriate opportunity to develop/attain the desired outcomes and attributes. For any particular unit of engineering management studies the desired outcomes and the learning experiences and assessment techniques employed will vary depending on what management competencies we are aiming to impart. On-campus students may be viewed as having an advantage over off-campus students in that they have easy access to
university resources and can easily collaborate formally or informally in group work. This may be true, but many off-campus engineering students have the advantage of maturity, organisational support from their employer and practical experience from working in the engineering workforce. The concept of recognition for prior learning acknowledges the value of prior formal education as well as experiential learning.

Whereas classroom activities may provide conventional entry students with the chance to develop teamwork and negotiation skills, and to understand the importance of dealing with customers, and documented case studies may permit on-campus students to appreciate the importance of quality management and organisational behaviour, many off-campus students will have already had direct experience of these issues. Where it is impractical or difficult to require an off-campus student to directly undertake a particular learning or assessment activity, because it requires proximity to other students or certain equipment, we should consider if:

- it can be facilitated by on-line communication, such as conducting a negotiation exercise using a CMC environment (a benefit here is that all exchanges are recorded for future review);
- it can be facilitated at another location, such as an off-campus student giving an oral presentation in their workplace and submitting a video tape and audience evaluations of the presentation for assessment; or
- whether a mature age student with workplace experience really needs to demonstrate the particular skill/competency; for example, students with workplace experience would generally have experienced group/team work.

Either automatically as a matter of course, or with suitable evidence/proof of experience (personal statements, witnessed testimonials, etc), it may be reasonable to exempt off-campus students from particular ‘practical’ activities on the basis of prior experience. However, if the basis for exemption is experiential learning alone, then it is important that these students complete the related theoretical component, so that they develop a theoretical underpinning that will allow them to contextualise their prior experience and understand the associated underlying principles, upon which they can base informed decision making in the future.
Flexible delivery that encompasses off-campus delivery means learning resources other than classroom presentation. Whether it is print, on-line or some combination, the learning materials must be collected in a permanent form. Off-campus study materials that are heavily based on custom written print materials are expensive to develop and maintain. As textbook editions change, or current thinking changes or as the direction of the course changes, large volumes of custom written print materials become a potential liability with the contingent risk of going out of date or requiring an onerous effort to keep refreshed. An alternative approach is to use an array of learning resources, including textbooks, sections of textbooks, journal papers, other printed material, on-line material, as well as custom written material, to provide students with the foundation they require to complete the learning activities required to attain the planned learning objectives. In practice, the key learning resource has traditionally often been a textbook. This pragmatic approach to the selection of instructional media is recognised as a reality of education and instructional design:

“In practical instructional situations, the media employed are often chosen on the grounds of availability, feasibility and cost.” (Gagné et al., 1988, 201).

For most science, technology and engineering applications areas, appropriate textbooks abound that provide a satisfactory coverage of the topic areas in question. However, a casual inspection of Table 2 (let alone Table 25 and Table 26) shows the wide range of topic areas that might be consigned together under the banner of ‘management studies’ in a small proportion of an undergraduate course. If the course aims to give a broad coverage of engineering management issues, then it is often difficult to find an appropriate single textbook that provides a good coverage of the required topics. Options here include:
• requiring students to purchase multiple textbooks (never popular);
• having a single textbook supported by printed course material and readings to ‘fill in the gaps’ of the required topic areas; or
• having no textbook supported by more extensive printed course material and readings.
If an Australian engineering context is desired, then the range of recent engineering management textbooks that don’t have financial examples in pounds sterling or don’t have US spelling are relatively limited. Many key issues in engineering management practice are related to geography including systems of government, business structures, the judicial system, industrial relations and the legal system. Given that perceived relevance of management studies to engineering is often cited as a problem for undergraduate students, then trying to deliver content using an overseas context that is beyond the current experience of the student is likely to exacerbate any problem of student motivation.

The Australian engineering management educator is left with a dilemma. If a textbook with a suitably wide range of content can be located, it may be an American or English text, where many Australian concepts and principles are not covered, thereby reducing the value of the text as a key teaching resource. However, developments in educational technology offer two possible solutions. The widespread adoption of on-line delivery in conjunction with changes in the copyright legislation that permit digital transmission of third party content means that, even without a textbook, a large array of digitised material can now be provided to students, either directly, based on storage of material on university servers, or indirectly by providing links to students so that they can retrieve it themselves from other sources. Examples of this type of information are the on-line databases subscribed to by the university that provide full text content of articles from hundreds of international journals and periodicals at no direct cost to students. In many cases, students can download and print Adobe Acrobat files of journal articles that reproduce the original appearance of the article, including diagrams, figures and tables.

Another possible solution based on emerging developments facilitated by technology and copyright is the concept of ‘custom publishing’. Textbook publishers can now create and publish a custom textbook incorporating original content and/or third party textbook content; Pearson Education, one of the largest educational publishers, offers the following information:
“Pearson Custom Publishing gives you the opportunity to draw on intellectual property from almost any source. Original material from you, copyrighted material including the vast amounts of material owned by Pearson Education...and materials from our discipline specific databases can be used in any combination to create a custom book that fits your requirements.” (Pearson Custom Publishing, 2000, ¶ 1).

Conceivably, a limited run textbook could be professionally produced and published that contains:

- original course material that may have previously supplied to students in print form; plus
- material from one or more of the titles owned by the publisher, perhaps one or more chapters from each title; plus
- material from one or more third party publishers, used with the permission of the copyright owner and/or under the provisions of the appropriate copyright act(s).

It is suggested that the cost for such a textbook could be less than a ‘normal’ textbook, as it will contain only that material selected as necessary. From the engineering management educator’s perspective, it is certainly an attractive prospect to be able to, in principle, ‘pick and choose and publish’ only those elements of content required, to produce a single textbook that covers the diversity of topic areas that might have to be addressed in a single study unit. This is definitely flexibility of the most desirable kind.

The literature contains many examples of computer-/information-/on-line technologies adding value and flexibility to management education generally, as well as to engineering management education. Two themes that appear often in the literature on this topic include partnering in the development and delivery of management education and the current predominance of on-line technology in postgraduate management education, rather than at the undergraduate level. Examples of the former include:

“This article demonstrates the viability of an innovation in management education: using information technology (IT) to create value-added partnerships

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between universities to ‘leverage’ students’ learning experience with multiple sets of resources and technology and a broad array of faculty skills and knowledge.” (Alavi et al., 1997, 1310); and

“This article describes the alliance of two universities to facilitate their entry in Internet-based distance learning. The report outlines the steps taken in launching graduate credit-bearing courses using the Web...” (Kroder et al., 1998, 66).

An example of an on-line postgraduate engineering management course that demonstrates that the concept of ‘partnership’ can mean more than just academic institutional partners is:

“The production of high-quality Web-based graduate courses needs a concerted team effort because of the complexity involved...The Drexel development team worked with a media technology company so that the essential spectrum of distance learning skills and expertise were available” (Morris et al., 1998, 5).

The focus in the literature, to date, on postgraduate management courses and on-line delivery may be driven by a desire to ensure that the students have both the technological resources and maturity to cope with on-line learning. The evidence presented in the current work suggests that undergraduate students at Deakin University, particularly the off-campus student group, but all students in general, have both the computing resources and the attitude to computers in education that would be conducive to the effective use of on-line delivery of a significant proportion of their educational experience in undergraduate engineering management studies.

Deakin University claims to provide engineering studies, including a significant element of management studies, in flexible delivery mode. The following section examines the current state of engineering management studies at Deakin and, in light of the current work, proposes changes to enhance both content and delivery.
7.5 Engineering management education at Deakin University

The current structure of Deakin’s Bachelor of Engineering courses, in all disciplines, includes a clearly identifiable core ‘management’ unit at each of the four nominal year levels, that is, one unit out of eight at each year level, or 12.5% of the notional course content. Table 8 provided an outline of the current management units at each year level, noting that the environmental engineering discipline replaces SEB421 Strategic Issues in Engineering with SEV430 Engineering Audits and QA Systems. This structure clearly satisfied the former IEAust ‘10% rule’ accreditation requirement and also clearly addresses the current accreditation requirements. While the IEAust claims to accredit some three year Bachelor of Technology (B Tech) courses (Institution of Engineers Australia, 2001), it does not yet have published accreditation criteria for BTech Courses. Four of the eight Deakin BTech discipline streams currently contain a core management unit in each of the three year levels in the course, and the remaining four discipline streams contain core management units in the first two years of their course. While the accreditation requirements that might be developed by the IEAust for BTech courses are unknown at this stage, the National Generic Competency Standards (Institution of Engineers Australia, 1999b) covering professional engineers and engineering technologists identify identical core and elective ‘units of competency’ for both occupational classifications, hence it can be assumed that engineering management studies will be included in some form in any future accreditation requirements for BTech courses.

Turning to the engineering management units listed in Table 8, they have served the School well, and being a core part of the School’s original unit offerings, they were initially developed in the early 1990s to cater for the first student cohorts entering the School. Based on experience in teaching all four units, a critical examination of these units reveals the following points.

A majority of these units have not changed more than cosmetically in the last five years. Some sections are highly theoretical and do not lend themselves to student engagement beyond recall of theory, though the assignments seem to help students contextualise the material. Much of the material was designed with the initial student cohort (Victorian manufacturing students) in mind, and this has influenced the
content and case studies presented. The student readership has widened significantly over the intervening years, so some consideration of other disciplines, other countries and other contexts is required. Originally, student numbers in the units in the upper year levels were relatively small, but have increased significantly as the commencing student numbers have grown and stabilised, making the teaching and assessment tasks in all year levels very intensive.

Throughout the four unit sequence, which has become more central to all discipline streams following the recent School course restructure, there is some duplication and some material of arguably limited value. General organisational management issues are treated at both the first and second year levels, and systems modelling is treated at both second and fourth year levels. Additionally the year levels in which some concepts are treated could possibly be improved, for example, first year-first semester students often struggle with the concepts of the societal context of technology and professional ethics.

While these units have served a valuable purpose (as evidenced by the evaluation of the management studies stream by recent Deakin engineering graduates presented in Chapter 3), the context in which these units exist has changed and it is an opportune time to reconsider the:

- aim(s) of the management stream;
- unit content;
- textbooks used;
- methods of teaching;
- sequence of content;
- links to the rest of the courses;
- opportunities for incorporating new teaching technologies; and
- methods of assessment.

Any such reconsideration of units and streams must take into account the existence of the Deakin University Teaching and Learning Management Plan (TLMP) (Deakin University, 2000). The TLMP identifies Deakin University’s strategic priorities for teaching and learning as:
• enhancing graduate attributes and outcomes;
• strengthening the teaching and learning experience; and
• extending internationalisation.

It also identifies the desired attributes of a Deakin graduate as encompassing:
• discipline specific attributes - including a systematic body of knowledge, an understanding of the professional, industrial and social contexts, and the ability to use textual, graphical and numerical information;
• generic attributes - including personal skills and citizenship.

The School of Engineering and Technology at Deakin University offers undergraduate engineering education programs (including a management studies stream), in Australia, via flexible delivery. Hence, the prior discussion is directly relevant to a reconsideration of undergraduate engineering management studies at Deakin. Any changes to the management studies stream should seek to enhance the relevance and value of the units to students, to increase teaching satisfaction and to make any such changes in a realistic and manageable manner.

The starting point is course/stream content - what should we teach the students? The framework developed in this project provides a guide, which must be adjusted according to the local constraints. The Deakin engineering student population is diverse, both in terms of engineering disciplines covered, as well as student demographics. A common management studies stream must provide a broad foundation on which graduates can base their professional practice and lifelong learning. Undergraduate studies (whether technical or management related) can only provide students with an introduction to a topic. Exposure to a wide range of topics assists graduates to ‘know where to look’ when they have to solve a real problem in practice. The evidence is that many engineers and technologists will pursue formal postgraduate studies in management. Management plays a central role in the long-term careers of most technology professionals, so a key aim of any undergraduate management program should be to expose students to this reality and help prepare them to deal with it.

Consideration must also be given to the method(s) of delivery employed. In the early 1990s, during its establishment phase, the new School of Engineering and
Technology at Deakin University enjoyed a ‘honeymoon’ period of seed funding and relatively low student numbers (Briggs, 1995). During this time a unit development and delivery model was developed that has served both the School and its students well. In reality, the model employed is a 1960s model of distance education underpinned by extensive print material. It is relatively labour intensive in development and expensive to produce and deliver. The School is now in a phase where it must be self-funding, and much of the course material developed in the initial phase now requires significant re-development. The School urgently requires a more efficient and sustainable course development and delivery model. While print has been the mainstay of the School’s flexible delivery model, the School has also historically been at the forefront on computer-based and on-line delivery activities across the University (Palmer and Tulloch, 2001), though this pre-eminent profile has diminished somewhat during recent years.

From the latter half of the 1990s significant effort has been devoted internationally to the development and evaluation of on-line course delivery models. At Deakin University various on-line delivery and support systems have been trialed, including commercial products such as WebCT (WebCT, 2001), FirstClass (Centrinity, 2001) and most recently TopClass (WBT Systems, 2001), as well as ‘home-grown’ solutions such as the Education Studies Online system (Faculty of Education Deakin University, 2001), the Psychology Warehouse (Faculty of Health and Behavioural Sciences Deakin University, 2001) and the School’s own unit Web page system (School of Engineering and Technology Deakin University, 2001). Previously, various factors have hindered the widespread adoption of on-line delivery. However recent developments have made on-line delivery a practical reality, these include:

- widespread Internet access;
- changes to copyright laws to permit digital delivery of third party content;
- increasing student demand for on-line delivery;
- emerging local and international competition based on on-line delivery;
- strategic support for on-line delivery from the central University (Deakin University, 2001); and
- evidence (presented in Chapter 6) that on-line delivery is not an equity issue for the School’s students.
The evidence internationally and from Deakin is that on-line delivery will be a major
element of all educational delivery in the near future. The School needs to plan, trial
and evaluate on-line delivery strategies to ensure it is well placed to tackle the
imminent challenges of on-line learning at Deakin. A key objective of any on-line
delivery developments should be to focus on generic on-line delivery strategies and
techniques that are not dependent on a particular proprietary product or technology,
so as to avoid obsolescence and costly re-development that has plagued some earlier
School developments in this area. An on-line delivery system should provide the
following features:

- minimum reliance on print-based resources;
- on-line submission and return of assignments and student feedback;
- timely and immediate update of learning resources during the teaching period;
- provision of identical learning resources for all student groups; and
- computer conferencing to permit communication between the various student
groups.

As noted previously, management studies are well suited to on-line delivery and
might be a logical starting place for the School to extend its forays into on-line
support and delivery of teaching and learning. Generic on-line development and
delivery model(s) piloted in this discipline area should be applicable to the School’s
wider unit offerings.

The current management units offer opportunities to incorporate new teaching
technologies. The existing unit study guides are very heavy in content (to make up
for the dearth of textbooks in this area). This creates a burden in development and
maintenance. An option in any stream re-design would be to provide more textbook
and on-line resources, and perhaps a single study guide that identifies learning goals
and guides students through the resources and required assessment tasks. The actual
learning resources could be changed regularly with little impact on the study guide.
The models/examples of on-line delivery from within Deakin cited above offer an
insight into how this might be achieved. Changes to the Copyright Act have opened
up possibilities in on-line delivery that were not possible previously. The range of
on-line journals/ databases provided by the Deakin Library has increased
dramatically, as has accessibility to these resources. It is envisaged that a move to a
significant on-line delivery component would be initially based on one of the two on-
line delivery platforms funded and supported by the central University, that is, either
FirstClass or TopClass. Experience suggests that both of these environments offer
the features required to support on-line delivery. In 2001 both systems suffered
major failures, coincidentally at the same time, suggesting that there is no clear
functionality or reliability criteria on which to select one system over the other.

The aim of basing a unit at each of the four year levels around a textbook highlights a
number of the practical constraints mentioned previously:

- the general lack of ‘Australian’ engineering management textbooks;
- the difficulty in finding any single engineering management textbook that
coherently covers the wide range of topic areas required for an undergraduate unit
that aims to provide a broad subject area coverage (evidenced by the fact that
SEB221 and SEB421 do not currently have prescribed texts); and
- that if an ‘appropriate’ textbook can be identified, its topic coverage will be a
major determinant of the unit content.

An iterative design process is required that:

- commences with an ‘ideal’ management studies stream structure; and
- attempts to identify an ‘ideal’ textbook for each study unit; then
- redistributes unit content among the study units, where possible, to find an
optimal balance between pedagogy and pragmatism, such that the management
stream syllabus is adjusted and distributed amongst the year levels to best match
the available textbooks and/or other learning resources.

This process must also include discussion, consultation and negotiation with other
stakeholders to take account of:

- the staff resources available to take responsibility for the (re-)development and
delivery of the various study units;
- the impacts of any proposed content and delivery changes on the course/
discipline streams served by the management studies stream - it must be kept in
mind that the management studies stream does not exist in its own right, it forms
a common core in all the engineering course/discipline streams;
that individual staff will have their own preferred approaches for delivery;
that some of the management units are offered under different unit codes in the
education programs of partner providers, for example Engineering Education
Australia (a commercial subsidiary of the IEAust that acts as an education broker)
offers SEB221 as SEB321, and SEB421 as SEB621 in some of its programs;
that the level one unit, SEB121, is regularly granted as advanced standing to
mature age students in recognition of their workplace experience encompassing
written and oral communication and practical management experience;
the level four unit SEB421 is not normally part of the BTech course, though some
BTech students take it as an elective unit in their program; and
other external constraints.
Whatever the outcome, it is unlikely that any single textbook will satisfy the desired
unit content requirements, and supplementary resources, in the form of readings
and/or references to on-line material, are still likely to be required and, in fact, may
be desired.

Based on a recent preliminary review of the engineering management studies stream
in the Deakin undergraduate engineering programs, Table 27 presents a possible
syllabus outline for a future engineering management stream that seeks to fulfil the
requirements discussed above. This proposed syllabus retains the core of the current
syllabus, but repositions some existing content to achieve a better match between the
content of individual units and existing commercial textbooks, such that a single
textbook could be reasonably assigned as one of the principal learning resources for
each unit. Some relevant new content available in these proposed textbooks has also
been added where appropriate. Some duplication of content that has occurred over
time in the existing syllabus is removed in the proposed syllabus. Finally, minor
changes to the year level of presentation of some topics have been changed to offer a
more coherent topic grouping within units, a logical progression and sequence of
content across units and to best match the nature of topics to the developing maturity
of undergraduate students. The current unit names may need to be changed to better
represent the changed content.
Table 27 - Possible syllabus outline for a future engineering management stream

<table>
<thead>
<tr>
<th>Year level and representative textbook</th>
<th>Syllabus outline</th>
</tr>
</thead>
</table>
| Year 1 (SEB121) Engineering Management (Kinsky, 1994) | • Communication skills  
• Introduction to management concepts  
• Accounting, finance & economics  
• Law for professionals |
| Year 2 (SEB221) Engineering & Society (Johnston et al., 1999) | • Technology perspectives  
• Professional practice  
• Environment & sustainability  
• Innovation and technology transfer  
• Occupational health and safety |
| Year 3 (SEB311) Quantitative Analysis for Management (Render and Stair, 2000) | • Project management  
• Modelling, simulation & forecasting  
• Decision making strategies  
• Operations research  
• Management information systems |
| Year 4 (SEB421) Management for Engineers (Samson, 2001) | • Strategic management  
• Managing design  
• Industrial relations & human resource management  
• Marketing  
• Creative thinking |

The syllabus presented in Table 27 represents the outcome of only the first pass through the iterative refinement/optimisation process, with limited input from other stakeholders, but it does provide a starting point for the reconsideration of the management studies stream in the undergraduate engineering programs at Deakin.

As noted in the literature and the project survey results, many of the ‘management’ skills that are highly valued are really generic skills, such as communications skills and leadership. Traditionally, in Australian undergraduate engineering education, the management studies stream has been viewed as the place where generic skills are taught/developed. While the author would argue that a wider range of units should explicitly aim to develop generic skills, it is clear that the management stream units will continue to play an important role in this area. Generic skills development requires some content (i.e., how to make an oral presentation, how to work effectively in teams), but after that they are best developed by practise. This can be achieved
through the design of assessment tasks that exercise them, ie oral presentations, group assignments, etc.

This traditional ‘segregation’ of management studies as the non-technical component of the course may contribute to the impression that some students get that management is not part of engineering. Wherever possible, the author uses real engineering/technology case studies to demonstrate the value of management studies. Currently, there is little evidence that the science and discipline-related technical units make any attempt to acknowledge the relevance of management issues or the wider societal context of technology. Doing this would not only increase the perceived relevance of the management units, it would also better prepare the students for the realities of professional practice, where they will find that technology does not stand in abstracted isolation from the societal context in which it is immersed.

An ideal undergraduate engineering management studies stream would be tightly integrated, logically sequenced, self consistent and coherent, as well as matching seamlessly with related postgraduate management units offered by the School and Faculty. However, the reality of the management studies stream at Deakin is far from ideal:

- some students will be exempted from one of more of the units because of RPL;
- some students will be taking one unit only as a stand-alone elective topic in another course;
- the units are offered in flexible mode for students studying off-campus and part time, conceivably only taking one of the management units every four years on average;
- some students who have departed from the recommended course study sequence will take the units ‘out of order’, as they attempt to fill in their semester timetable to ensure a full class load; and
- the units are common to virtually all of the undergraduate courses, in their various discipline flavours, offered by the School, and hence must be all things to all people.
The need to be both integrated and flexible and to cater for a very wide audience creates compromises in the design and delivery of the management units. The key to addressing this dilemma is to be both fixed and flexible. The learning outcomes of a unit can be documented in both specific and general terms. The specific outcomes will apply to all students, and while the general outcomes will also apply to all students, they can be contextualised by the student to suit their individual circumstances. The fixed course component is realised in core unit content that is implemented in the form of key learning resources supplied to all students, and may also include some identically prescribed assessment tasks to be completed by all students. The flexible course component is realised by one or more of the assessment tasks that the students must undertake in completing the unit. These assessment tasks can be designed to allow the students to explore general principles learned in the unit in the context of their personal circumstances, these may include one or more of:

- the technical discipline being studied by the student;
- the requirements of their workplace; and
- their personal interests.

The aim of this approach is that students themselves find the relevance of their studies to their personal circumstances, and when they do this, their interest in and engagement with the course material is heightened.

Consider the cases of two ‘first year’ engineering students undertaking an engineering management assignment asking them to locate an engineering-related organisation, identify its mission statement and analyse its strategic plan. A conventional entry on-campus student normally consults the publicly available information on a major public company (Ford, Holden, BHP), often sourcing this information from the Internet, or may perhaps base their assignment on a smaller organisation that a friend or relative works for. A small proportion of these students would seek direct contact with the organisation to obtain additional information and/or interview a representative of the organisation. A mature age off-campus student typically uses their employer/workplace, or in some cases their own business as the case study. In one extreme case, a mature age student used an assignment exercise such as this as the basis for the initial strategic planning exercise for a business he had just purchased and become a director of. On completion of the
assignment, all students (hopefully) have understood the nature and importance of the strategic planning exercise, and have been able to gain this understanding in a manner most appropriate to their personal experiences and current needs.

This section has identified some of the characteristics of, current limitations of, and practical constraints on, the undergraduate engineering management studies stream at Deakin University. In light of the project work documented in this thesis, an initial outline of a possible future management stream structure was presented, along with a concept for individual unit development based on minimal custom-developed print resources, on-line delivery/support and assessment designed to contextualise the learning experience for individual students. The proposed development concept is viewed as a way forward for the undergraduate engineering management stream at Deakin, as well as offering a development path for the School’s wider unit offerings.

At the time of writing, the author had been successful in obtaining a School teaching grant to plan and develop the proposed model for the management unit SEB421 Strategic Issues in Engineering in semester two of 2001, for initial delivery to students in semester two 2002.

Looking further into the future, it is the belief of the author that the IEAust’s new accreditation requirements relating to management studies weaken the claim that management studies have to a significant place in an undergraduate course. At Deakin, the ‘one unit out of eight each year’ status currently enjoyed by the management studies stream may come under review. As elsewhere, at Deakin there is also a wide spread of opinion relating to the value of engineering management studies, and there may be pressure to marginalise management studies in favour of more traditional technical content. On a positive note, it is noted that in the most recent course review undertaken by the School, the management studies stream did survive intact and core to most course offerings. As a final point of discussion, the following section will examine the current status of undergraduate engineering management education generally in Australia.
7.6 Engineering management education in Australia

As identified in Chapter 2, the status of engineering management in Australia could be viewed as having passed it zenith and now in a state of comparative decline. By 1990 the IEAust policies mandated a management studies component in accredited undergraduate courses, starting at 5% in 1991 phasing up to 10% by 1995 - the ‘10% rule’. However, by 1997 (and re-confirmed in a 1999 revision) the new IEAust accreditation requirements had subsumed engineering management, along with professional ethics, into a general requirement for exposure to ‘engineering practice’, which should account for ‘about 10%’ of the course.

This change of emphasis, which weakens and marginalises engineering management studies, highlights a long-standing division in the thinking of the stakeholders in the development of IEAust accreditation policy. Lloyd (1994) reports on the formulation and ratification of the 1990 IEAust policy on management studies in undergraduate programs. A draft of the policy released in 1989 generated comments from a large number of interested stakeholders. The principal negative comments were received from two senior engineering academics who were of the opinion that the primary objective of engineering education is “to produce a competent technical problem solver”, that the model study structure (presented in Table 2) was “too comprehensive...pretentious in it specifications” and that the idea that degrees are too technical should be abandoned (Lloyd, 1994, 219). Feedback from many other academics and practising engineers was positive and supportive of the draft proposal.

Chapter 2 identified that by 1999 close to 30% of Australian engineering courses fell ‘well short’ of the 10% requirement for management studies; clearly in these institutions management studies were not considered important, even though they were a course accreditation requirement. The 1996 Johnson review of engineering education in Australia starkly demonstrates the differing opinions; while supporting the need for engineering education to include the broad context of engineering practice, including “…economics, finance, accounting, teamwork and competition…”, the following passage may also be found:
“Management training represents a narrowing, not broadening of educational offerings. It would be a gross injustice to the students who study engineering because of intrinsic interest in the subject and who want to practice engineering to find their engineering education being turned into a mere launching pad for a new breed of aspiring managers...While it is true that upper level management jobs command high incomes, there are, in fact, few of them...If engineering education is to take a turn in this direction, it is likely to lead to a dead end” (Johnson, 1996b, 44).

While it is true that there are not enough middle- or other management jobs for all of those, including engineers, who might aspire to them, these statements seem to ignore the reality that much engineering practice involves the management of self, other people, information, equipment, projects, materials, capital and other finances. The survey of recent graduates included in Chapter 3 showed that even recent graduates have valued and found application for their undergraduate management studies. While it may be less than desirable for the management content of an engineering course to exclusively focus on management science and managerialism, it is difficult to conclude that the current IEAust accreditation requirement of about 10% professional practice studies (with some fraction of this 10% devoted to ‘management’) represents a narrowing of engineering education.

Clearly, in Australia, there is still vigorous debate as to the need for, and value of, management studies in undergraduate engineering courses. Regardless of the long standing recognition and documented importance of management in the practice of engineering, even for recent graduates, there are still some that view management as ‘not part of engineering’. The new accreditation requirement relating to undergraduate management studies could be seen unflatteringly as a movement of the goalposts to ensure that all institutions and courses will now satisfy the criteria without any further attention to management studies. Contrast this situation with that in the United States, where the Accreditation Board for Engineering and Technology (ABET) includes engineering management amongst the more traditional engineering course disciplines that it accredits (Farr and Bowman, 1999).
One way to reconcile the view that management studies are not necessary at the undergraduate level and yet still permit management to be an important aspect of engineering practice is to propose that engineering management skills are best studied at the postgraduate level. It is found internationally that the most common first degree discipline of MBA students is engineering, and in Australia 15% of engineers study an MBA, more than four times greater than the number that study a higher degree in engineering. If undergraduate education instils the importance of lifelong learning into engineering graduates, then they can pick up any skills and knowledge (including management) that they might require at a later date. There can be no argument that, in an environment of change, lifelong learning or continuous professional development (CPD) is essential. In an engineering context, Seethamraju and Agrawal (1996) actually suggest that certain management skills, including self-management and people management are experience orientated and hence better learned post graduation on the job.

In reality, undergraduate and postgraduate studies are just two phases in a continuum of lifelong learning required to attain and maintain technical competence and currency of knowledge. They are not mutually exclusive. The survey of Australian academics involved in the design and delivery of undergraduate engineering management education presented in Chapter 3 found that 87.5% of respondents indicated that management studies should be included in the undergraduate phase of education, and the same proportion, 87.5%, indicated that management studies should be included in the postgraduate phase - it doesn’t have to be one phase at the expense of the other. Hecker (1997) reflecting on the skills required for success in consulting engineering identified three key issues:
1. the need and importance of non-technical skills;
2. the importance of providing basic soft skills training in engineering undergraduate programs; and
3. measures that organisations can take to promote lifelong learning of these skills. She also notes that:

“Most firms desire to employ new graduates with client relations skills. The teaching of these skills has not typically been a significant emphasis of
engineering education. If the basic purpose of formal engineering education is to provide an opportunity for the individuals to learn fundamental engineering principles, why is so much more needed by employers?...More aggressive competitors and more demanding clients require that engineers develop a whole range of skills beyond technical competence.” (Hecker, 1997, 62).

It is clear that undergraduate education (whatever the discipline) cannot prepare a graduate for every eventuality in their career - this is the purpose of postgraduate education and the rationale for lifelong learning. However, just as the technical component of undergraduate engineering education strives to produce competent engineers that are immediately productive in practice and who have a foundation of knowledge and skills which can be developed by workplace experience and further study, undergraduate studies should also prepare engineering graduates for the reality of practice that non-technical issues will play an increasingly important role in their work and their career development. The evidence presented in this report and elsewhere is that management plays a central role in the long-term careers of most technology professionals. Hence a key aim of any undergraduate engineering program should be to expose students to this reality and help prepare them to deal with it. While such exposure is likely to be only an introduction to this area, exposure to a range engineering management issues will assist graduates to ‘know where to look’ when they have to solve real management problems in practice.

So where does this leave undergraduate engineering management studies in Australia? There is still no unanimous agreement that management studies should be part of undergraduate engineering education. Management studies are identified in the IEAust accreditation requirements for undergraduate engineering programs. However the terminology used is not clear - management studies are considered part of an exposure to ‘professional engineering practice’, the total of which should be ‘about 10%’ of the program. The surveys presented in this report (including those documented in the literature) suggest that the management skills reported as most useful span a very wide range that is dependent on the practice and experience of the respondent. Can any coherent conclusions be drawn from this situation? Yes.
The Johnson review of Australian engineering education canvassed and included the contributions of a large number of participants. It represented a diversity of opinion regarding undergraduate engineering education in Australia. While it contains opinions that are not supportive of undergraduate engineering management studies, it also contains many that are, and in its final recommendations it does recognise the importance of management to the professional practice of engineers. The revised IEAust accreditation requirements flowing from the Johnson review also identify at least ‘some’ requirement for management studies in undergraduate programs. A key point regarding the new accreditation requirements is that they have moved from being strongly prescriptive of course inputs, to being focussed on graduate outcomes/attributes. Additionally, quality assurance mechanisms have been introduced which include wide stakeholder participation in the design and evaluation of undergraduate programs. The accreditation requirements have moved from a principally input driven, open loop model to an output focussed, closed loop model that includes controlling input informed by the practice of professional engineering. While the new accreditation system is still bedding down across undergraduate engineering education in Australia, there is reason to believe that, in programs that are genuinely informed by the practice of professional engineering, then engineering management studies will receive the prominence they deserve in the context of the particular undergraduate program.

Just as the IEAust accreditation requirements have moved from being prescriptive to a model that permits engineering undergraduate programs to respond to local conditions within an overarching structure and quality assurance mechanism, the management skills framework developed in this project provides guidance as to the relative importance of various classifications of management skills/competencies. It would be expected that most programs would incorporate coverage of the majority of the generic professional practice skills identified. Other generic management skills might also be included. Discipline specific management skills would be included depending on the discipline flavour of the program. Some theoretical management skills and skills related to other professional disciplines might be included to provide graduates with a broader perspective on management and effective communication across the organisation. A proactive undergraduate program would include relevant
management studies to prepare their graduates for emerging trends in engineering management.
8 - Conclusion

8.1 General

Engineering management is the management of the engineering function and/or the application of engineering principles to the task of technical and/or general management. It can be described in terms of the ‘management functions’ typically carried out by the engineering manager, but just what any particular engineering manager does is contingent on the organisational setting and career stage of the individual. Historically, the importance of management to the practising engineer, and hence to the undergraduate preparation of engineers, is well documented. In Australia this was acknowledged in 1991 with the IEAust accreditation requirement that undergraduate courses contain approximately 10% management studies. However, the future status of undergraduate engineering management education is less certain. Recent changes to the IEAust’s course accreditation requirements reduce the perceived importance of management studies.

Based on surveys of Australian engineering management academics, mature age engineering students and recent graduates of Deakin's engineering programs, and supported by an investigation of the related literature, a framework of ranked classified management skills was developed. This framework is described further in Proposition A below.

The aforementioned framework identifies the importance of generic professional practice skills. A key element in the development of these skills is practise, and assessment tasks are one of the principal determinants of the ‘practise’ that undergraduate students carry out in their studies. An investigation of assessment tasks designed to develop generic professional practice skills suggests that students do value these exercises, but that skills that require abstract critical ability (such as peer- and self-assessment and critical self-reflection) need to be introduced carefully and in a context that assists students to appreciate the value of these skills.

The flexible delivery of education fundamentally changes the nature of education from a service to a product, as well as dramatically increasing the diversity of the
demographics of the student population. The delivery of a product requires new and flexible organisational infrastructure and systems, and a much broader audience requires course content and delivery methods that cater for the diverse backgrounds, objectives and capabilities of the students. Over time, flexible delivery is coming to be seen to mean (at least partly) on-line delivery. While not necessarily unique to the on-line environment, the issues that must be addressed in the on-line delivery of education include equity of access, the cost of technological infrastructure, copyright and intellectual property, content development methodologies, administration systems, staff development, cultural change and the financial sustainability of on-line developments.

Based on surveys of large undergraduate student groups using on-line technologies as part of engineering management studies, it is concluded that this student group is well prepared and able to use on-line technologies, undergraduate management studies are well suited to the application of on-line technologies and this student group developed a generally positive attitude to the use of on-line technologies in their management studies. These findings are discussed further in Proposition B below.

8.2 Proposition a)

The management skills and competencies required by graduate engineers can be determined and classified on a rational basis, permitting an educational focus on those elements most appropriate for graduates.

Based on an examination of the literature and original research undertaken as part of this project, a framework of ranked classified management skills was developed in Chapter 3 and discussed in Chapter 7 (see Table 25). Broadly, the ranking framework is generic professional skills first, followed by general management skills and technical discipline specific management skills, followed by other professional discipline skills and theoretical skills. This framework provides a rational basis for design of undergraduate engineering management studies. This is supplemented by consideration of the management skills required for the future of engineering practice given in Table 26. The framework does not claim to be prescriptive in nature,
exhaustive in identification of important management skills, or definitive in the sub-
ranking of the importance of the skills listed within each of the three broad
categories. Any individual practising engineer might select as important a subset of
those management skills presented, to which they might add other items important to
them in their particular circumstances and/or they might re-classify particular skills
depending on their area of practice.

8.3 Proposition b)

On-line and other computer-based technologies are a practical and effective method
for the support of undergraduate engineering management studies.

Based on an examination of the literature and original research undertaken as part of
this project, it is concluded that undergraduate engineering management education is
well suited to delivery and support by on-line and computer-based technology. The
evidence suggests that on-line delivery will be a central component of education and
training in the future. While engineering education generally requires innovative
strategies to overcome the inherent difficulties of satisfying laboratory and
experimental/practical work requirements in the flexible delivery mode, many
aspects of engineering management studies (and management studies in general) do
not require experimental work, and are hence well suited to on-line delivery. Recent
developments in improved access to the Internet, software systems for on-line
collaboration and changes in copyright legislation to create a broad-based right to
communication via on-line media have all facilitated on-line delivery of teaching and
learning. It is noted that now that many on-line infrastructure issues have been
satisfactorily resolved, higher level issues will emerge as crucial, including the
academic staff development and reward for operating in an on-line teaching
environment, and the financial sustainability of on-line development and delivery of
courses. The research documented in this report suggests that Deakin engineering
students are well placed to benefit from on-line support of their education generally,
but that the inherent differences of the two principal students groups (on- and off-
campus) need to be recognised and catered for in the development of flexible
delivery strategies.
8.4 Other conclusions

At Deakin University, undergraduate engineering management education currently enjoys a relatively privileged status in the School of Engineering and Technology. A reconsideration of the aims of the engineering management studies stream would be opportune not only to refresh the stream content, but also to adapt the content and delivery to take advantage of new on-line teaching technologies.

An historical barrier to the flexible delivery of engineering management education in Australia has been the issue of appropriate textbooks. The need to cover a wide range of topics in a single unit normally means prescribing multiple textbooks or custom producing course notes. New developments arising from the convergence of computing, information and communications technologies offer possible solutions to the cost effective and convenient provision of flexible learning materials in engineering management. These developments include custom publishing, where the required sections from various textbooks and other sources can be combined into a unique, short-run printed book for students, and the increasing availability of on-line databases providing full-text access to a wide range of journals, magazines and other periodicals offering students access to up-to-date learning and research resources via the Internet at a time and place of their convenience.

8.5 Recommendations for future work

As already noted, the concept of a definitive list of management skills required by engineers is not a realistic goal, as the disciplines of engineering and management are both dependent on technology and society, neither of which are static. To maintain currency, any list of engineering management skills needs to be periodically refreshed by research into the current state of play in the practice of engineering management. This is a task that should be conducted again in no more than five year’s time.

While the research presented in this project included a wide review of the related international literature and a national survey of Australian academic staff involved in undergraduate engineering management education, the key research was derived from a survey of recent graduates from Deakin’s engineering programs. The results showed that these graduates work in a diverse array of employment situations, hence
the outcomes developed should be generally applicable, and are particularly relevant for the consideration of Deakin’s engineering management studies stream undertaken in this project. With appropriate resources a wider survey of practising Australian engineers could be conducted to establish those management skills important in general Australian engineering practice. Such a survey would probably require the participation of the IEAust and other Australian engineering professional associations to establish the identity of practising professional engineers in Australia.

While the literature establishes the importance of on-line learning for engineers and the feasibility of delivering management education via on-line channels, the research documented in this project related principally to the used of a CMC system for assignment submission, communication and on-line collaboration. The emergence of full on-line courses for engineering in the near future will require research in the following areas related to the effectiveness of full on-line delivery:

- reliability of on-line infrastructure and systems;
- cost effectiveness of on-line development and delivery;
- accessibility/equity of education opportunities for those with limited Internet access or physical disabilities not currently catered for by on-line delivery;
- the importance of staff development for educators in the effective use of on-line delivery;
- student training requirements for effective use of on-line delivery;
- new educational opportunities provided/created by on-line delivery;
- demonstration of general graduate attribute attainment - as required by the IEAust course accreditation requirements; and
- strategies and techniques for the development of those engineering management skills that currently employ proximal interpersonal interaction, such as oral presentation, team work and leadership.
List of References


http://www.contract.kent.edu/change/articles/marapr96.html.


Institution of Engineers Australia. (1993). *National Competency Standards for Professional Engineers (Stages 1 and 2)*. Barton, ACT: Institution of Engineers, Australia.


Institution of Engineers Australia. (2000). Interim Policy on Accreditation of Programs Offered in Distance Mode. Canberra: Institution of Engineers, Australia.


Baccalaureate Program and Contextual Basis. *Journal of Engineering
Education, 84*(3), 225-234.
Kulandaisswamy, V. C. and Mandke, V. V. (1995). Planing for Flexible and Distance
Learning in Engineering: Indian Experience. *European Journal of
estimation models accurate? *Information and Software Technology, 32*(3),
187-190.
Inventory Management Journal, 40*(1), 43-51.
the Current State of Affairs in the Business World. *Institute of Industrial
Engineers Solutions, 29*(12), 16-19.
University.
Prentice-Hall Inc.
The FLOW Project.* Proceedings of the Australasian Association for
Engineering Education 8th Annual Convention and Conference, Sydney, 230-
234.
Internet Mediated Laboratory Experiments.* Proceedings of the 1st Asia-
Engineers, Australia for the New Millennium.* Canberra: Institution of
Engineers, Australia.


Mallick, D. N. and Chaudhury, A. (2000). Technology Management Education in MBA Programs: A Comparative Study of Knowledge and Skill


Paul, R. H. (1990). *Open Learning and Open Management: Leadership and Integrity in Distance Education*. London: Kogan Page Ltd.

PE Consulting Group (Australia) Pty Ltd. (1972). *The Role of the Professional Engineer*. Melbourne, Australia: Australian Commission on Advanced Education.


WebCT. (2001). WeB'T (Version 3.5) [Computer software]. Lynnfield, Massachusetts: WebCT.


Bibliography


Association for Engineering Education 8th Annual Convention and Conference, Sydney, 235-239.


Appendix A - Questionnaire sent to Australian engineering management academics
Dear colleague,

Re: Questionnaire Plain Language Statement

This Plain Language Statement is an invitation to participate in a research project aimed at understanding the management perspectives of academics involved in engineering management education in Australia. This Plain Language Statement provides an outline of the research project so that you may make an informed decision to participate or not.

My name is Stuart Palmer and I am a lecturer in the School of Engineering and Technology at Deakin University. My contact details should you wish to contact me are as follows:

Address - School of Engineering and Technology
Deakin University
GEELONG
VIC 3217

Phone- (03) 5227 2818
Fax- (03) 5227 2167
E-mail - spalm@deakin.edu.au

As an educator involved in engineering management education in Australia, it is likely that you have practice experience of engineering management, as well as experience of the nature of teaching, learning and research in higher education. This combination of experience offers a unique perspective on the engineering management education process.

This research project proposes to add to the understanding of engineering management by determining the management competencies considered important by academics involved in engineering management education in Australia, and by documenting some characteristics and perspectives of academics involved in engineering management education in Australia.
The research procedure involved is a questionnaire directed at academics involved in engineering management education in Australia, a copy of which is included with this Plain Language Statement.

It is expected that the questionnaire will take no more than 20 minutes to complete, and participation will not subject you to any risk, stress or discomfort. A consent form is included, which must be signed and dated by yourself and returned with the questionnaire to indicate that you consent to participate in this research project.

The questionnaire is completely anonymous and will remain confidential, your signed consent form will be stored separately from your questionnaire, and no connection can be made between you and your questionnaire responses. Research data obtained will be securely stored in a locked cabinet in an office within the School of Engineering and Technology at Deakin University.

Your participation in this research project is completely voluntary, you are free to not participate or withdraw at any time without any adverse consequences.

All participants who return a completed questionnaire and consent form will be sent a summary of the research results once they are collated, this is a small reward for your effort to complete and return the questionnaire.

Please note that consolidated, summary statistics of participant responses may be published. Where illustrative or informative, individual participant descriptive responses may be published, but there will be no record of the identify of the participant.

If you consent to participate in this research project, please complete the attached questionnaire and consent form, and return them in the reply paid envelope provided. Please note that it does not cost you anything to use the reply paid envelope, and you do not need to attach a stamp to it.

Should you (ie, participant) have any concerns about the conduct of this research project, please contact the Secretary, Deakin University Ethics Committee, Research Services, Deakin University, 221 Burwood Highway, BURWOOD, VIC 3215. Tel (03) 9251 7123.

Yours sincerely

Stuart Palmer
Lecturer, School of Engineering and Technology
**Engineering Management Academics’ Questionnaire**

This is anonymous questionnaire. Please ensure that you do not write your name, or any other comments that will make you identifiable on this form. You must complete the attached Consent Form and return it with the questionnaire to indicate your informed consent to take part in this research. You should also read the enclosed Plain Language Statement carefully as it explains fully the intention of this project.

This questionnaire aims to add to the understanding of engineering management by determining the management competencies considered important by academics involved in engineering management education in Australia, and by documenting some characteristics and perspectives of academics involved in engineering management education in Australia.

---

1. General

Please state your age at your last birthday ...................................................... [ ] Years

Please indicate your gender (circle M or F) ................................................. M   F

If you hold an academic qualification(s) in engineering, science or technology, please list it/them here .................................................. ..................................................

If you hold an academic qualification(s) in management, commerce or business, please list it/them here ..................................................

Please indicate how many years (in total) you have worked in the engineering workforce (if nil, please indicate ‘nil’) ....................... [ ] Years

Please indicate how many years (in total) you have worked in a management capacity (if nil, please indicate ‘nil’) ......................... [ ] Years

Please indicate how many years (in total) you have worked in a lecturing/teaching capacity (if nil, please indicate ‘nil’) ................. [ ] Years

2. Engineering Management

In your opinion, is engineering management different from general management? (Circle Y or N) ........................................... Y   N

What are the reasons for your conclusion?

If there is not enough room for you, please write on another page and attach it to this questionnaire.

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In your opinion, is it inevitable that most practicing engineers will find themselves in an engineering management role for a significant part of their careers? (Circle Y or N) ................. Y  N

What are the reasons for your conclusion? If there is not enough room for you, please write on another page and attach it to this questionnaire.

3. Management Competencies

The Institution of Engineers Australia’s (IEAust’s) Guidelines for Management Studies in Engineering Undergraduate Courses provides a suggested model management studies program that includes the topics listed below. For each of these competencies / skills, please indicate whether, in your experience / opinion, they are not important, important, or very important.

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<thead>
<tr>
<th>Competency</th>
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<td>Communication skills</td>
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<td>Legal studies</td>
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<td>Engineering and society</td>
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<td>Economic evaluation of projects</td>
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<td>Operations and quality management</td>
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<td>Project management</td>
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Please list any other management competencies / skills that you consider necessary for
engineers, and using the same rating scale as above, please indicate whether, in your experience / opinion, they are not important, important, or very important. If there is not enough room for you, please write them on another page and attach it to this questionnaire.

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4. Engineering Management Education
In your opinion, is the most important phase for engineering management education undergraduate, postgraduate or both? (Circle U/G or P/G or both) .......................................................... U/G P/G

What are the reasons for your conclusion?
If there is not enough room for you, please write on another page and attach it to this questionnaire.

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In the space provided here, please list any advice you would give to undergraduate students regarding engineering management.
If there is not enough room for you, please write on another page and attach it to this questionnaire.

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In the space provided here, please list any advice you would give to practicing engineers regarding engineering management. If there is not enough room for you, please write on another page and attach it to this questionnaire.

In the space provided here, please describe how you feel engineering undergraduate management education in Australia could be improved. If there is not enough room for you, please write on another page and attach it to this questionnaire.

Thank you for your time and cooperation.

Please return the completed questionnaire and consent form in the reply paid envelope provided. Please note that it does not cost you anything to use the reply paid envelope, and you do not need to attach a stamp to it.
Appendix B - Questionnaire sent to mature age engineering students
Dear Off-campus Engineering and Technology Student,

Re: Questionnaire Plain Language Statement

This Plain Language Statement is an invitation to participate in a research project aimed at understanding the management perspectives of mature age engineering students. This Plain Language Statement provides an outline of the research project so that you may make an informed decision to participate or not.

My name is Stuart Palmer and I am a lecturer in the School of Engineering and Technology at Deakin University. My contact details should you wish to contact me are as follows:

Address - School of Engineering and Technology
Deakin University
GEELONG
VIC 3217

Phone- (03) 5227 2818
Fax- (03) 5227 2167
E-mail - spalm@deakin.edu.au

As an off-campus engineering student (this includes both the Bachelor of Engineering and Bachelor of Technology) it is highly likely that you are a mature age student and that you have some experience of the engineering workforce.

This research project proposes to add to the understanding of engineering management by determining the management competencies considered important by mature age engineering students, and by documenting the engineering management experiences of mature age engineering students.

The research procedure involved is a questionnaire directed at mature age engineering students, a copy of which is included with this Plain Language Statement.
It is expected that the questionnaire will take no more than 15 minutes to complete, and participation will not subject you to any risk, stress or discomfort. A consent form is included, which must be signed and dated by yourself and returned with the questionnaire to indicate that you consent to participate in this research project.

The questionnaire is completely anonymous and will remain confidential, your signed consent form will be stored separately from your questionnaire, and no connection can be made between you and your questionnaire responses. Research data obtained will be securely stored in a locked cabinet in an office within the School of Engineering and Technology at Deakin University.

Your participation in this research project is completely voluntary, you are free to not participate or withdraw at any time without any adverse consequences.

All participants who return a completed questionnaire and consent form will be sent a summary of the research results once they are collated, this is a small reward for your effort to complete and return the questionnaire.

Please note that consolidated, summary statistics of participant responses may be published. Where illustrative or informative, individual participant descriptive responses may be published, but there will be no record of the identity of the participant.

If you consent to participate in this research project, please complete the attached questionnaire and consent form, and return them in the reply paid envelope provided. **Please note that it does not cost you anything to use the reply paid envelope, and you do not need to attach a stamp to it.**

Should you (ie, participant) have any concerns about the conduct of this research project, please contact the Secretary, Deakin University Ethics Committee, Research Services, Deakin University, 221 Burwood Highway, BURWOOD, VIC 3215. Tel (03) 9251 7123.

Yours sincerely


Stuart Palmer
Lecturer, School of Engineering and Technology
Mature Age Engineering Student Management Experience Questionnaire

This is anonymous questionnaire. Please ensure that you do not write your name, or any other comments that will make you identifiable on this form. You must complete the attached Consent Form and return it with the questionnaire to indicate your informed consent to take part in this research. You should also read the enclosed Plain Language Statement carefully as it explains fully the intention of this project.
This questionnaire aims to determine the management competencies / skills considered important by mature age engineering students, and to document the engineering management experiences of mature age engineering students.

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1. General
Please state your age at your last birthday ........................................... [ ] Years
Please indicate your gender (circle M or F) ................................. M F
Please state what country you currently reside in ......................... ....................................
Please state your previous highest academic qualification, (ie. HSC, VCE, TAFE Diploma, etc) .................................................... ....................................
Please indicate how many years (in total) you have worked in the engineering workforce (if nil, please indicate ‘nil’) .............. [ ] Years
Please indicate the course you are enrolled in (circle one) ........... BE BTech Other
If ‘Other’, please indicate what course ..................................................
Please indicate which discipline you are enrolled in (circle one) .. Coast. Res. Man. Computronics Environmental Manufacturing Mechatronics

2. Management Competencies
The Institution of Engineers Australia’s (IEAust’s) Guidelines for Management Studies in Engineering Undergraduate Courses provides a suggested model management studies program that includes the topics listed below.
For each of these competencies / skills, please indicate whether, in your experience / opinion, they are not important, important, or very important.

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Please list any other management competencies / skills that you consider necessary for engineers, and using the same rating scale as above, please indicate whether, in your experience / opinion, they are not important, important, or very important. If there is not enough room for you, please write them on another page and attach it to this questionnaire.

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3. Management Experience
In the space provided here, please describe any management experience you have had, this would include any roles you have had as a team leader, supervisor, project manager, area manager, etc, regardless of the organisational title of those roles. If there is not enough room for you, please write on another page and attach it to this questionnaire.

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4. Experiences of Engineering Management
Have you ever been supervised / managed by a qualified professional engineer? (circle Y or N) .............................................. Y  N

If yes, in the space provided here, please describe your experiences of being managed by an engineer - positive, negative or otherwise. Please describe your experience of each engineering manager you have had.
If there is not enough room for you, please write on another page and attach it to this questionnaire.

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In the space provided here, please include any other comments / thoughts / ideas you have regarding engineering management and your experiences of management by engineers.
If there is not enough room for you, please write on another page and attach it to this questionnaire.
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Thank you for your time and cooperation.
Please return the completed questionnaire and consent form in the reply paid envelope provided. Please note that it does not cost you anything to use the reply paid envelope, and you do not need to attach a stamp to it.
Appendix C - Questionnaire sent to recent Deakin engineering and technology graduates
Dear Deakin Engineering and Technology Graduate,

Re: Questionnaire Plain Language Statement

This Plain Language Statement is an invitation to participate in a research project aimed at better understanding the management competencies required by engineers in professional practice and the education processes required to develop those competencies. This Plain Language Statement provides an outline of the research project so that you may make an informed decision to participate or not.

My name is Stuart Palmer and I am a lecturer in the School of Engineering and Technology at Deakin University. My contact details should you wish to contact me are as follows:

Address - School of Engineering and Technology
Deakin University
GEELONG
VIC 3217

Phone- (03) 5227 2818
Fax- (03) 5227 2167
E-mail - spalm@deakin.edu.au

As a graduate of the Deakin School of Engineering and Technology, you will have completed some studies in the area of engineering management (the SEBxxx units), in on- and/or off-campus mode. This research project aims to add to the understanding of engineering management and flexible teaching & learning by ascertaining:

- the management skills perceived as valuable by graduates of Deakin engineering and technology undergraduate programs; and
- whether the graduates perceive their undergraduate studies were effective in providing them with the management skills they have required in professional practice.
The research procedure involved is a questionnaire directed at a number of graduates of the Deakin School of Engineering and Technology, a copy of which is included with this Plain Language Statement.

It is expected that the questionnaire will take no more than 20 minutes to complete, and participation will not subject you to any risk, stress or discomfort. A consent form is included, which must be signed and dated by yourself and returned with the questionnaire to indicate that you consent to participate in this research project.

The questionnaire is completely anonymous and will remain confidential. Your signed consent form will be coded and stored separately from your questionnaire, and no connection can be made between you and your questionnaire responses. Research data obtained will be securely stored in a locked cabinet in an office within the School of Engineering and Technology at Deakin University.

Your participation in this research project is completely voluntary, you are free to not participate or withdraw at any time without any adverse consequences. If you chose to withdraw, your questionnaire will be identified by its code and removed from the research data.

All participants who return a completed questionnaire and consent form will be sent a summary of the research results once they are collated, this is a small reward for your effort to complete and return the questionnaire.

If you have any questions about this research project, please contact me using the contact details given above.

If you consent to participate in this research project, please complete the attached questionnaire and consent form, and return them in the reply paid envelope provided. **Please note that it does not cost you anything to use the reply paid envelope, and you do not need to attach a stamp to it.**

Yours sincerely

Stuart Palmer
Lecturer, School of Engineering and Technology

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Should you have any concerns about the conduct of this research project, please contact the Secretary, Ethics Committee, Research Services, Deakin University, 221 Burwood Highway, BURWOOD VIC 3125. Tel (03) 9251 7123 (International +61 3 9251 7123).
Deakin Engineering & Technology Graduates’ Questionnaire

This is anonymous questionnaire. Please ensure that you do not write your name, or any other comments that will make you identifiable on this form. You must complete the attached Consent Form and return it with the questionnaire to indicate your informed consent to take part in this research. You should also read the enclosed Plain Language Statement carefully as it explains fully the intention of this project.

This questionnaire aims to add to the understanding of engineering management and flexible teaching & learning by ascertaining:

- the management skills perceived as valuable by graduates of Deakin engineering and technology undergraduate programs; and
- whether the graduates perceive their undergraduate studies were effective in providing them with the management skills they have required in professional practice

1. General
Please state your age at your last birthday ........................................... [ ] Years

Please indicate your gender (circle M or F) ............................... M F

Please indicate the qualification you graduated with ...................... BTech BE

Please indicate your principal mode of study as an undergraduate (circle On-campus of Off-campus) ............................................. On Off

Please indicate the discipline in which you majored, (ie Manufacturing, Mechatronics, etc) .................................................. 

Please state the year in which you finalised your studies .......... 199

Please indicate how many years (in total) you have worked in the engineering workforce since graduating (if nil, please indicate ‘nil’) .......................................................... [ ] Years

Please indicate the industry sector you are currently employed in (ie automotive, food, local government, etc) .......................... 

Please indicate the job function that you currently perform (ie designer, testing, production, QA, sales, etc) ............................

2. Management skills
Please indicate any management roles that you have held (ie supervisor, team leader, project manager, unit manager, etc).

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Based on your experience, what management skills have been the most important/relevant in your work? (circle any from the list below).

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<tr>
<th>Communication skills</th>
<th>Project management</th>
<th>Legal / law</th>
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<tr>
<td>Supervision &amp; leadership</td>
<td>Accounting &amp; finance</td>
<td>Economics</td>
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<td>Quality management</td>
<td>Professional ethics</td>
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<td>Organisational behaviour</td>
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<td>Design management</td>
<td>Supply management</td>
<td>Change management</td>
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<td>Dealing with customers</td>
<td>Decision making</td>
<td>Negotiation</td>
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<td>Report writing</td>
<td>Contract management</td>
<td>Forecasting</td>
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<td>Motivation</td>
<td>Competition</td>
<td>Conflict resolution</td>
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<td>Occupat. health &amp; safety</td>
<td>Creativity</td>
<td>Information management</td>
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<td>Logistics</td>
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In the space below, please indicate any other management skills that have been important/relevant in your work.

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3. Course effectiveness
Using a scale of 1 = strongly disagree, 2 = partially disagree, 3 = unsure, 4 = partially agree and 5 = strongly agree, please indicate your level of agreement for the following statements (circle the number that shows your agreement).

Overall, the engineering management component of your undergraduate studies has been of value to you .................. 1 2 3 4 5

If you entered engineering directly from secondary school...
...your management studies helped prepare you for real engineering practice .......................................................... 1 2 3 4 5
If you entered engineering as a mature age student...
...your management studies helped formalise your understanding of management gained from your prior work experience.............. 1 2 3 4 5

If you studied principally on-campus as an undergraduate...
...your classroom activities and assessment tasks helped develop your understanding of engineering management................................. 1 2 3 4 5

If you studied principally off-campus as an undergraduate...
...your course materials and assessment tasks helped develop your understanding of engineering management................................. 1 2 3 4 5

In the space below, please indicate any aspects of your undergraduate engineering management studies that you feel WERE particularly useful/relevant you.

....................................................................................................................................................................................
....................................................................................................................................................................................
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In the space below, please indicate any aspects of your undergraduate engineering management studies that you feel WERE NOT particularly useful/relevant you.

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....................................................................................................................................................................................

In the space below, please indicate any ways in which you feel your undergraduate engineering management studies could have been improved (in terms of content, method of delivery, assessment, etc) to make them more useful/relevant to you.

....................................................................................................................................................................................
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Thank you for your time and cooperation.
Please return the completed questionnaire and consent form in the reply paid envelope provided. Please note that it does not cost you anything to use the reply paid envelope, and you do not need to attach a stamp to it.
Appendix D - Questionnaire used at start of semester for evaluation of assessment methods
### SEB421 START OF SEMESTER CLASS SURVEY 1997

This brief survey is aimed at determining the general level of exposure of the class, as a whole, to the teaching and learning methods we will be using in SEB421 this semester. It will be used to evaluate the effectiveness of these teaching methods.

In some questions below, you will be asked if you agree with a statement. If **you strongly agree** with the statement, circle 5, if you **strongly disagree** with the statement, circle 1, if you **somewhat agree**, circle 4, if you **somewhat disagree**, circle 2, if you are **undecided**, circle 3.

Please note that this survey is anonymous, and the results will not be able to be related to any individual student.

<table>
<thead>
<tr>
<th><strong>General</strong></th>
<th></th>
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<tbody>
<tr>
<td>Please state your age at your last birthday</td>
<td>[ ] Yes</td>
</tr>
<tr>
<td>Please indicate your gender (circle M or F)</td>
<td>M F</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th><strong>Group work</strong></th>
<th></th>
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</thead>
<tbody>
<tr>
<td>In your previous studies, have you ever participated in group work that was assessable? (circle Y or N)</td>
<td>Y N</td>
</tr>
<tr>
<td>Do you think that working in groups is better than working individually? ( S = ) strongly agree, ( I = ) strongly disagree</td>
<td>1 2 3 4 5</td>
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<table>
<thead>
<tr>
<th><strong>Case studies</strong></th>
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<tbody>
<tr>
<td>In your previous studies, have you ever undertaken a case study where you have had to undertake research on a topic and write up a report or make a presentation? (circle Y or N)</td>
<td>Y N</td>
</tr>
<tr>
<td>Do you think that case study exercises are a valuable learning tool? ( S = ) strongly agree, ( I = ) strongly disagree</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

<table>
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<tr>
<th><strong>Report writing</strong></th>
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<tbody>
<tr>
<td>In your previous studies, have you ever had to prepare a written report for an assignment? (circle Y or N)</td>
<td>Y N</td>
</tr>
<tr>
<td>Do you think that preparing written reports is a valuable exercise? ( S = ) strongly agree, ( I = ) strongly disagree</td>
<td>1 2 3 4 5</td>
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<thead>
<tr>
<th><strong>Oral presentation</strong></th>
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<tbody>
<tr>
<td>In your previous studies, have you ever had to make an oral presentation to a group? (circle Y or N)</td>
<td>Y N</td>
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</tbody>
</table>

| **Do you think that giving oral presentations to groups is a valuable exercise? \( S = \) strongly agree, \( I = \) strongly disagree | 1 2 3 4 5 |

<table>
<thead>
<tr>
<th><strong>Self assessment</strong></th>
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<tbody>
<tr>
<td>In your previous studies, have you ever encountered self-assessment, where you have contributed to the mark you obtained on a piece of work? (circle Y or N)</td>
<td>Y N</td>
</tr>
<tr>
<td>Do you think that self-assessment, where you contribute to the mark you get for a piece of work, is better than assessment solely by the teacher? ( S = ) strongly agree, ( I = ) strongly disagree</td>
<td>1 2 3 4 5</td>
</tr>
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<tr>
<th><strong>Industrial interviews</strong></th>
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</thead>
<tbody>
<tr>
<td>In your previous studies, have you ever had to visit and interview a member of an engineering company? (circle Y or N)</td>
<td>Y N</td>
</tr>
<tr>
<td>Do you think that visiting and interviewing a member of an engineering company would be a valuable exercise? ( S = ) strongly agree, ( I = ) strongly disagree</td>
<td>1 2 3 4 5</td>
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<tr>
<th><strong>Reflective journals</strong></th>
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<tbody>
<tr>
<td>In your previous studies, have you ever had to compile a journal or diary where you documented your understanding of, or thoughts about the material studied in class? (circle Y or N)</td>
<td>Y N</td>
</tr>
<tr>
<td>Do you think that keeping a journal of your thoughts and ideas about the material studied in class would be a valuable exercise? ( S = ) strongly agree, ( I = ) strongly disagree</td>
<td>1 2 3 4 5</td>
</tr>
</tbody>
</table>

Thank you for your time and cooperation.
Appendix E - Questionnaire used at end of semester for evaluation of assessment methods
SEB421 END OF SEMESTER CLASS SURVEY 1997

This follow-up survey is aimed at evaluating the effectiveness of these teaching methods used in SEB421 this semester. Your participation would be greatly appreciated.

In some questions below, you will be asked if you agree with a statement. If you strongly agree with the statement, circle 5, if you strongly disagree with the statement, circle 1, if you somewhat agree, circle 4, if you somewhat disagree, circle 2, if you are undecided, circle 3.

In some questions below, you will be asked open ended questions to which you can respond as you wish. If you would like to write more than will fit in the space provided, please continue on the back of the page, labelling your note with the question number it belongs to.

Please note that this survey is anonymous, and the results will not be able to be related to any individual student or group of students.

Group work
Do you think that working in groups is better than working individually?
(5=strongly agree, 1=strongly disagree) ................................................................. 1 2 3 4 5

What do you perceive the positive and negative aspects of group work to be? -

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Case studies
Do you think that case study exercises are a valuable learning tool?
(5=strongly agree, 1=strongly disagree) ................................................................. 1 2 3 4 5

What do you perceive the positive and negative aspects of case study exercises to be?

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

Report writing
Do you think that preparing written reports is a valuable exercise?
(5=strongly agree, 1=strongly disagree) ................................................................. 1 2 3 4 5

What do you perceive the positive and negative aspects of report writing to be? -

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________

__________________________________________________________________________
**Oral presentation**
Do you think that giving oral presentations to groups is a valuable exercise? *(5=strongly agree, 1=strongly disagree)* ................................................................. 1 2 3 4 5

What do you perceive the positive and negative aspects of oral presentations to be? -

<table>
<thead>
<tr>
<th>Positive aspects</th>
<th>Negative aspects</th>
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</table>

**Self assessment**
Do you think that self-assessment, where you contribute to the mark you get for a piece of work, is better than assessment solely by the teacher? *(5=strongly agree, 1=strongly disagree)* ................................................................. 1 2 3 4 5

What do you perceive the positive and negative aspects of self-assessment to be? -

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<thead>
<tr>
<th>Positive aspects</th>
<th>Negative aspects</th>
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</tbody>
</table>

**Industrial interviews**
Do you think that visiting and interviewing a member of an engineering company would be a valuable exercise? *(5=strongly agree, 1=strongly disagree)* ................. 1 2 3 4 5

What do you perceive the positive and negative aspects of industrial interviews to be? -

<table>
<thead>
<tr>
<th>Positive aspects</th>
<th>Negative aspects</th>
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**Reflective journals**
Do you think that keeping a journal of your thoughts and ideas about the material studies in class would be a valuable exercise? *(5=strongly agree, 1=strongly disagree)* ................................................................. 1 2 3 4 5

What do you perceive the positive and negative aspects of reflective journals to be? -

<table>
<thead>
<tr>
<th>Positive aspects</th>
<th>Negative aspects</th>
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General
Please state your age at your last birthday .................................................. [ ] Yrs

Please indicate your gender (circle M or F) .................................................. M F

What did you enjoy most about SEB421? -

________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________
________________________________________________________________________

What did you enjoy least about SEB421? -

________________________________________________________________________
________________________________________________________________________
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If you could change any aspect of SEB421, what would it be? -

________________________________________________________________________
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Thank you for your time and cooperation.
Appendix F - Questionnaire used to ascertain computer usage patterns
Dear Off-campus SEB121 Student,

Re: Computer Usage Survey

Welcome to SEB121 for 1998. You should have your study materials by now, and be planning your study program for the semester.

Please find enclosed a short survey form on your computer usage. This survey is aimed at determining the general level of exposure to, and use of computers, by the class, as a whole. It will be used to help improve the computer resources and training provided to engineering and technology students.

Please note that participation is voluntary, all data will remain anonymous and confidential. The results may be published, but only in an aggregate form, results will not be related to any individual student.

I hope that you can find a couple of minutes to complete the survey and return it in the reply paid envelope to me. Please note that there is no charge to you to use the reply paid envelope, and you do not need to put a stamp on it. Deakin pays for the postage when it arrives back at the University.

Good luck for your studies in 1998!

Yours sincerely

Stuart Palmer
Lecturer, SEB121 1998
Schol of Engineering and Technology
This brief survey is aimed at determining the general level of exposure to, and use of computers, by the class, as a whole. It will be used to help improve the computer resources and training provided to engineering and technology students.

Please note that participation is voluntary, all data will remain anonymous and confidential. The results may be published, but only in an aggregate form, results will not be related to any individual student.

By completing this form you consent to participate in this survey.

1. **General**
   - Please state your age at your last birthday ................. [   ] Yrs
   - Please indicate your gender (circle M or F) ................. M  F
   - Please indicate your study mode (circle On or Off-campus) . On  Off

2. **Computer Usage**
   - Have you used a computer before? (circle Y or N) ........... Y  N
   - Do you use a computer regularly? (circle Y or N) ............ Y  N

4. **Internet Usage**
   - Do you regularly use e-mail? (circle Y or N) ................. Y  N
     - If yes, do you use your own e-mail account, or do you use someone else's? (circle one) - Own Acct / Someone else's
   - Do you regularly use the World Wide Web? (circle Y or N) . Y  N
   - Have you ever created a Web page? (circle Y or N) ........... Y  N
     - Do you have access to the Internet/WWW? (circle Y or N) . Y  N
       - If yes, where do you have access? (circle one)
         - Home / Work / School / University / Other

3. **Computer Access**
   - Do you have access to a computer? (circle Y or N) .......... Y  N

5. **Other**
   - What do you think computers most useful for? ............... 
   - What task do you use computers for most? ....................
   - What computer program do you use the most? .................

**Thank you for your time and cooperation**
Appendix G - Questionnaire used at start of semester to ascertain computer attitudes and experiences
DEAKIN UNIVERSITY ETHICS COMMITTEE
PLAIN LANGUAGE STATEMENT

Dear SEB121 Student,

This Plain Language Statement is an invitation to participate in a research project aimed at understanding the attitudes to, and experiences of computer usage in a commencing engineering and technology student group. The results of the survey will form a base line for comparison to a follow-up survey at the end of the semester, following a computer-based learning component in this unit.

The research project is being undertaken by Mr Stuart Palmer, the unit chair for SEB121. The research project will involve participants completing a short questionnaire on your attitudes to, and experiences of computer usage. The questionnaire should take no more than five minutes to complete. Your participation in this project will not effect your result in this or any other unit.

The questionnaire asks for your age, gender, study mode and opinions, but is completely anonymous. All research data obtained will remain confidential; no one other than the researcher will have access to it. In accordance with Deakin University guidelines, research data will be stored securely in the Faculty of Science and Technology at Deakin University.

Consolidated, summary statistics of participant responses may be published. Where illustrative or informative, individual participant descriptive responses may be published, but there will be no record of the identity of the participant.

A summary of the research results will be made available to participants via the unit Web site:

http://www.et.deakin.edu.au/unit/unit_home.asp?unit=SEB121

Participation is completely voluntary. You are free to participate or not to any extent, and free to withdraw at any time. If participation is withdrawn, any information gathered will not be used and will be destroyed.

If you have any questions about this research project, please contact:

Mr Stuart Palmer
School of Engineering and Technology
Deakin University
GEELONG
VIC 3217
Phone -(03) 5227 2818
Fax - (03) 5227 2167
E-mail - spalm@deakin.edu.au

Should you have any concerns about the conduct of this research project, please contact the Secretary, Ethics Committee, Research Services, Deakin University, 221 Burwood Highway, BURWOOD VIC 3125. Tel (03) 9251 7123 (International +61 3 9251 7123).
# Computer attitude and experience survey

This is an anonymous questionnaire. Please do not write your name or any other thing that might identify you on it.

1. **General**
   - Please state your age at your last birthday: [ ] Yrs
   - Please indicate your gender (circle M or F): M F
   - Please indicate your study mode (circle On or Off-campus): On Off

2. **Computer / Internet access**
   - Do you have access to a computer? (circle Y or N): Y N
   - If yes, who does the computer belong to? (circle one)
     - You / Your family / Your employer / A friend / Other
     - If ‘Other’, please specify who it belongs to: 
   - Do you have access to the Internet/WWW? (circle Y or N): Y N
   - If yes, where do you have access? (circle one)
     - Home / Work / School / University / Other
     - If ‘Other’, please specify where you have access: 
   - Do you have access to e-mail? (circle Y or N): Y N
   - If yes, where do you have access? (circle one)
     - Home / Work / School / University / Other
     - If ‘Other’, please specify where you have access: 

3. **Computer usage**
   - Do you use a computer regularly? (circle Y or N): Y N
   - How many hours per week (on average) do you spend using a computer? [ ] Hrs
   - Do you regularly use e-mail? (circle Y or N): Y N
   - Do you regularly use the World Wide Web? (circle Y or N): Y N

4. **Computers are useful for...**
   - (Please tick those selections that you agree with)
     - Games
     - Internet
     - Teaching / learning
     - Assignments
     - Other (please specify)

5. **I use computers for...**
   - (Please tick those selections that you agree with)
     - Games
     - Internet
     - Teaching / learning
     - Assignments
     - Other (please specify)
   - What computer program do you use the most?

6. **For teaching and learning at University...**
   - (Please tick the selections that you must agree with)
     - Learning from computers could never replace classes / lectures
     - Computers could never assist my learning
     - Computers could assist my learning
     - Learning from computers would be better than classes / lectures

Thank you for your time and cooperation.
Appendix H - Questionnaire used at end of semester to ascertain computer attitudes and experiences
Dear SEB121 Student,

This Plain Language Statement is an invitation to participate in a research project aimed at understanding the attitudes to, and experiences of computer usage in the SEB121 student group following the introduction of a computer-based learning component in this unit. The results of the survey will form a comparison to the baseline survey conducted at the start of the semester, prior to the computer-based learning component in this unit.

The research project is being undertaken by Mr Stuart Palmer, the unit chair for SEB121. The research project will involve participants completing a short questionnaire on your attitudes to, and experiences of computer usage. The questionnaire should take no more than five minutes to complete. **Your participation in this project will not effect your result in this or any other unit.**

The questionnaire asks for your age, gender, study mode and opinions, but is completely anonymous. All research data obtained will remain confidential; no one other than the researcher will have access to it. In accordance with Deakin University guidelines, research data will be stored securely in the Faculty of Science and Technology at Deakin University.

Consolidated, summary statistics of participant responses may be published. Where illustrative or informative, individual participant descriptive responses may be published, but there will be no record of the identity of the participant.

A summary of the research results will be made available to participants via the unit Web site:  
http://www.et.deakin.edu.au/unit/unit_home.asp?unit=SEB121

Participation is completely voluntary. You are free to participate or not to any extent, and free to withdraw at any time. If participation is withdrawn, any information gathered will not be used and will be destroyed.

If you have any questions about this research project, please contact:

Mr Stuart Palmer  
School of Engineering and Technology  
Deakin University  
GEE LONG  
VIC 3217  
Phone- (03) 5227 2818  
Fax- (03) 5227 2167  
E-mail - spalm@deakin.edu.au

Should you have any concerns about the conduct of this research project, please contact the Secretary, Ethics Committee, Research Services, Deakin University, 221 Burwood Highway, BURWOOD VIC 3125. Tel (03) 9251 7123 (International +61 3 9251 7123).
End of semester - Computer attitude and experience survey

This is an anonymous questionnaire. Please do not write your name or any other thing that might identify you on it.

1. General
   Please state your age at your last birthday ......................... [   ] Yrs
   Please indicate your gender (circle M or F) ......................... M F
   Please indicate your study mode (circle On or Off-campus) ....... On Off

2. Computer usage
   How many hours per week (on average) do you spend using a computer? ................................................. [   ] Hrs
   Do you regularly use e-mail? (circle Y or N) ...................... Y N
   Do you regularly use the World Wide Web? (circle Y or N) ...................... Y N

3. The FirstClass conferencing system
   How many times (approx) did you access the FirstClass conferencing system during semester 1 1999? ......................... [   ] times

   Please indicate your main method of accessing the FirstClass system (tick the appropriate selection below)
   Web Browser  □  FirstClass client program □

4. I use computers for...
   (Please tick those selections that you agree with)
   Games □  Internet □  Teaching / learning □
   Assignments □  Other □ (please specify) ...........................

   What computer program do you use the most? ..............................

5. For teaching and learning at University...
   (Please tick the selections at the top of the next column that you most agree with)

   □ Learning from computers could never replace classes / lectures
   □ Computers could never assist my learning
   □ Computers could assist my learning
   □ Learning from computers would be better than classes / lectures

6. Using the FirstClass conferencing system
   Using a scale of 1=strongly disagree, 2=partially disagree, 3=unsure, 4=partially agree & 5=strongly agree, please indicate your level of agreement for the following statements (circle the number that shows your agreement)

   The FirstClass system was easy to access 1 2 3 4 5
   The FirstClass system was easy to use 1 2 3 4 5
   The FirstClass system helped me complete my assignment 2 1 3 4 5
   I regularly read the messages posted by other students 1 2 3 4 5
   Assignment 2 has helped me understand the unit material 1 2 3 4 5
   Using FirstClass would help me in other units I’m studying 1 2 3 4 5

   (Please tick those selections that you agree with)
   □ I used FirstClass to communicate with other on-campus students
   □ I used FirstClass to communicate with other off-campus students
   □ I used FirstClass to communicate with other students
   □ I didn’t use FirstClass to communicate with other students

7. Other
   How could the FirstClass system be improved? ..............................

   ..............................................................................................................
   ..............................................................................................................

   Thank you for your time and cooperation
Appendix I - Explanation of statistical inferences

Statistical comparisons have been used at various points in this research project to test the significance of observed values and distributions of values. These are explained below.

Two-sample \( t \) test of means
Used to make inferences (based on the \( t \) distribution) about the mean values from two independent random samples from distributions approximating the Gaussian distribution.

Large sample \( t \) test of proportions
Used to make inferences (based on the \( t \) distribution approximating the Gaussian distribution for large samples) about the proportions observed in samples.

Chi-square goodness-of-fit test for distributions of qualitative variables
Used to make comparisons (based on the \( \chi^2 \) distribution) of the distributions of qualitative variables in two large samples.

Chi-square test of independence of two qualitative variables
Used to make inferences (based on the \( \chi^2 \) distribution) about the independence of two qualitative variables in large random samples.

\( F \) test for comparison of several means
Used to conduct parametric analysis of variance (based on the \( F \) distribution) to compare the mean values of independent observations approximating the Gaussian distribution.

Significance level - \( p \)
The significance of a statistical inference is given by the \( p \) value. The \( p \) value represents the probability under the null hypothesis of seeing a result as extreme or more extreme than the observed result. Hence the smaller the \( p \) value, the more
likely the observed result is significant. For example, a $p$ value of 0.01 indicates that there is only a one percent chance of seeing the observed result by chance. The significance level criteria used to determine whether an observed results is significant or not is arbitrary and depends on many factors, including the nature of the experiment and the data obtained, the consequences of accepting or rejecting the null hypothesis, the conventions used by the researcher, etc. Typical $p$ values considered statistically significant are 0.01 and 0.05. The following conventions for significance level were used in this project:

\[
\begin{align*}
p &< 0.05 \quad \text{Significant} \\
0.05 &\leq p < 0.015 \quad \text{Borderline significant} \\
0.15 &\leq p \quad \text{Not significant}
\end{align*}
\]