This is the author’s final peer reviewed version of the item published as:


**Copyright**: 1999, Inderscience Enterprises
Engineering management studies as part of continuing engineering education

Stuart Palmer
Senior Lecturer, School of Engineering and Technology, Deakin University, Geelong, Victoria, Australia, 3216
E-mail: spalm@deakin.edu.au

Abstract: Engineering management is an important area of undergraduate preparation. 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. This paper reports on a survey undertaken to better understand the perceptions of mature age engineering students relating to engineering management. The engineering management competencies identified as most important by mature age engineering students are those that are practically orientated, most clearly associated with engineering and generic professional skills. Management competencies identified as less important by mature age students are those that are more theoretical and most clearly associated with other business functions or professional occupations.

Keywords: continuing engineering education; engineering management education; flexible delivery; mature age engineering students; management competencies; management skills; recognition of prior learning.

Biographical Notes: Stuart graduated in electronics engineering, and worked in private industry for eight years with a consulting engineering firm. Working in electronic design, industrial automation and process control, he progressed from project engineer to senior engineer to business unit manager. In that time he also completed a Master of Business Administration in Technology Management. In 1995 Stuart joined the School of Engineering and Technology at Deakin University, where he holds the position of senior lecturer, lecturing in Technology Management at undergraduate and postgraduate levels. Stuart is currently engaged in Doctoral studies, and his research interests include engineering education, the use of new media in education and the relationship between technology and society.

1 Introduction

Engineering management is an important area of undergraduate preparation. 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. This paper reports on a survey
undertaken to better understand the perceptions of mature age engineering students relating to engineering management.

2 The importance of management studies for engineering undergraduates

Research in Australia over the last three decades has established the importance of management competencies/skills for professional engineers and engineering technologists. 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.

A 1972 Australian survey of 1426 practising engineers by PE Consulting [1] found that 92% of respondents indicated management studies should be included at the undergraduate level. Lloyd, et al in [2] in 1979 highlighted the wide variation and general lack of management studies in Australian undergraduate engineering courses, stressed the crucial nature of engineering management skills for the nation, and identified that the formation of engineering managers must begin in undergraduate courses. The 1988 Discipline Review of engineering education in Australia [3] surveyed both final year students and graduates and found that the course areas with the greatest discrepancy between required and actual emphasis were development of self-confidence and an understanding of motivation, industrial relations / management of people, engineering as part of the broader business context, the management of costs and resources, and oral communication skills. The recent review of engineering education in Australia [4] (sponsored by the Institution of Engineers, Australia (IEAust), the Academy of Technological Sciences and Engineering, and the Australian Council of Engineering Deans) reaffirms the importance of instilling graduates with an understanding of the context in which engineering functions, including, “...economics, finance, accounting, teamwork and competition...”.

Recent international reviews of engineering education report similar findings. The American Society for Engineering Education concludes, “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.” [5]. The Canadian Academy of Engineering recommends, “Engineering Faculties should:...emphasize design, problem solving, the impact of engineering on society and the environment, communication, teamwork, leadership and practical experience...” [6]. 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.).” [7].

3 Flexible programs for continuing engineering education
The Australian review [4] also proposes 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 [8] 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. Many engineering organisations worldwide are currently establishing links with engineering Schools to provide their staff with customised, flexible programs delivered into their workplaces [9] [10].

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 [11] [12] [13]. 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 [14]. Flexible learning programs with RPL mean that a significant proportion of students enrolled may be mature-age and may have many years of experience working in the engineering workforce.

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 [15]. 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 [16] and they 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, the details and results of which are described below.

4 The survey

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 [17]. 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 [17]. 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 below. 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. Participation in the survey was voluntary, as required by the University’s ethics procedures.

5 Results and discussion

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 [18]).

In Australia the national secondary school certificate is known variously as the Higher School Certificate (HSC), Victorian Certificate of Education (VCE) and other similar titles. In Australia the vocational and trade education sector is known as Technical and Further Education (TAFE). In Figure 1 above, the normal progression 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 [19].

The 1991 Australian document *Guidelines for Management Studies in Engineering Undergraduate Courses* [20] provides a model undergraduate engineering management curriculum composed of 17 units of study. 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 below show 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).

![Perceived importance of management skills](image-url)
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.

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. Examining the seven elements ranked highest, it appears that these skills are identified as being ‘part of engineering’ (ie. project management, operations and quality management, etc) or important generic professional practice skills (ie. communication skills, supervision and leadership, etc). The first seven, highest ranked elements are highly practical, action-oriented activities 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. 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. organisational behaviour, management science, etc) or that they are closely identified with other (non-engineering) professions/business functions (ie. legal studies, marketing, accounting, etc).

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 concerning, and suggests that this area of study is important for mature age students, as well as conventional entry undergraduate students.

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 2 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.

Respondents were asked to identify any other areas of management competency/skill that they considered important for professional engineers, the list of all additional responses is given in table 1.

Table 1  Other management competencies identified as important

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

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, but not really part of engineering management;
- **IT Management**: a new and important skills 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 perhaps viewed as lacking in some of the practising professional engineers that they currently work with.

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, this is perhaps due to the fact that most of the respondents are still studying for their first professional qualification, and are unlikely to yet hold senior management positions.

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 2 below summarises all responses received and demonstrates that a majority of the management experience reported by respondents relates to the engineering workforce.

**Table 2** Prior management/supervision experience reported by respondents

- Supervision of unskilled labour
- Supervision of technical staff
- Manage priority and completion of maintenance jobs
- Supervision of site installation
- Supervise juniors in a retail department
- Management of engineering projects
- Supervision of trade staff
- Training laboratory staff
- Production supervision
- Planning and supply management
- Project manager for commissioning new production line
- Manager of company waste initiative
- Supervisor of water treatment plant
- Construction manager
- Manager of division of chemical manufacturer
- Managed educational programs
- Service manager in mechanical workshop
- Workshop manager
- Factory QA manager
- Drafting supervisor
- Site supervisor for construction of new plant
- Management in the hospitality industry
- Supervision of SMT facility
- Area manager for computer service company
- Team leader
- Project manager
- Training and development of engineering staff
- Team leader for a cosmetic company
6 Conclusions

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 engineering management competencies identified as most important by mature age engineering students are those that are practically orientated, most clearly associated with engineering and generic professional skills. Management competencies identified as less important by mature age students are those that are more theoretical and most clearly associated with other business functions or professional occupations. The competency element Engineering and Society was found to have a relatively low importance in the survey group; given that lack of appreciation of the societal context of science and technology is a common criticism of the profession, this suggests that this area of study is important for mature age students. A majority of respondents reported prior experience in a management role, and a majority of the management experiences reported relate to engineering work.

References

1 PE Consulting Group (Australia) Pty Ltd (1972) The Role of the Professional Engineer, Melbourne: Australian Commission on Advanced Education.


