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AN EXERCISE TO IMPROVE CAREER UNDERSTANDING OF COMMENCING ENGINEERING AND TECHNOLOGY STUDENTS

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The literature suggests that many commencing engineering students do not have an accurate understanding of the nature of professional practice in their chosen career. Many of the methods for exposing students to professional practice are impractical for large classes of commencing students. An assessment activity involving students collecting job advertisements for professional engineering positions and analysing them for required skills and knowledge was trailed and evaluated. It was found that a significant majority (86.2 percent) of students reported at least some change in their understanding of professional engineering practice. No significant difference was observed in these response rates between the three demographic categories (gender, study mode and course of study) of respondents. Student written comments about how their understanding of professional engineering practice had changed indicated that they benefited from, and valued exposure to aspects of professional engineering practice early in their undergraduate studies.

The literature suggests that many commencing engineering students do not have an accurate understanding of the nature of professional practice in their chosen career. This may be due to the poor understanding of engineering in the general population, and exacerbated by traditional engineering undergraduate education methods that concentrate on science and mathematics in the early years of the course, and don't expose

undergraduates to engineering practice until these 'foundation' studies are completed. While there are methods for exposing students to professional engineering practice, many of them are not practical for the large class sizes common in commencing engineering studies. A method documented in the literature involved students collecting job advertisements for professional engineering positions and analysing them for required skills and knowledge. This paper reports on the application of this method with a group of commencing engineering and technology students at Deakin University in Australia. The aims of this career development exercise were: to enhance the student's own career decision making based on a better understanding of typical professional practice in their prospective careers; to assist students to take increased responsibility for their own career path; and to help motivate students in their studies by clarifying their expectations about their likely roles in engineering employment post graduation. An evaluation of the exercise was undertaken to assess its effectiveness in improving the career understanding of the students, and the findings are reported here.

STUDENT UNDERSTANDING OF ENGINEERING PRACTICE

Do undergraduate engineering students have an accurate perception of the nature of professional engineering practice? There is evidence that some students do not. According to Kuo and Deuermeyer (1998), "Few IE [industrial engineering] students understand what industrial engineering is at the beginning of their education program and, more sadly, few improve their understanding by graduation" (p. 18). Williams (2001) reports on interviews with environmental engineering graduates to examine their professional socialization, "…there was generally a poor understanding of what environmental engineering would cover at university, and many interviewees could not envisage (at entry) what the career would involve." (p. 177). Pullin (1999) reporting on the UK Institute of Employment

Studies' annual graduate review in 1999 describes a, "…none to happy portrait of a mismatch of expectations and aspirations between graduates and their potential employers, in which recruiters are too often disappointed with what they are getting and the recruited too do not get what they want" (p. 30). Even on the very practical issue of salary expectations, Betts (1996) reports on a survey of 1269 undergraduates (including 592 engineering students) where the median error in student's beliefs about the salaries of their intended profession was approximately 20 percent. An accurate understanding of professional practice is valuable for students in planning their study program, "Some engineering students, even juniors and seniors, still do not know what an engineer does in the workforce. Some also may not have analyzed their coursework and internship plans to ensure graduating with skills necessary to land their targeted job." (Sharp, Olds, Miller, & Dyrud, 1999, p. 53).

There are more consequences of poor career / occupational understanding than unmet expectations at the time of graduation. Engineering has one of the highest undergraduate attrition rates, and for commencing engineering students career indecision has been identified as a critical factor in predicting student academic success. Haislett and Hafer (1990) report on the development of a procedure to predict at-risk commencing engineering student that incorporates a measure of career indecision, the aim being to offer career counselling at an early age to clarify occupational understanding or to suggest an early transfer to another study major area. Traditional undergraduate engineering programs required commencing students to, "…sit through two years of theoretical math, physics and engineering principles classes before actually getting their hands on an engineering project" (Bellinger, 1998, p. 147). The insistence that students acquire all the 'required' foundation knowledge prior to exposure to engineering applications meant that commencing students with no experience of engineering practice had to endure an extended period of alienation

from their chosen professional area, and for some of these students this period of career indecision was too long and they left engineering for another major, or dropped out of higher education altogether. Even the traditional methods of university teaching in engineering do not foster an appreciation of the nature of engineering practice, "…traditional lecture-based curriculums stress only technical ability. A new engineering education paradigm is needed, based on active, project-based learning." (Prados, 1997, p. 97).

There are a number of factors that may contribute to the poor appreciation of engineering practice in some commencing engineering students. Modern professional engineering encompasses a wide range of disciplines. Carlson (1991) reports that in the US in 1880, there were only three recognized disciplines of engineering; the current Accreditation Board for Engineering and Technology lists 33 different engineering disciplines for which accredited undergraduate courses exist (Accreditation Board for Engineering and Technology, 2000). Lloyd, Ferguson, Palmer & Rice (2001) report that in 1920 six engineering disciplines were offered in Australian universities, by 1979 this number has risen to 17 and in 2000, 54 disciplines could be found on offer. The recognized engineering disciplines span a broad array including aerospace, electrical, geological, nuclear and systems; altogether encompassing a wide diversity of knowledge, skills and work environments. It's impossible to easily describe the possible practice experiences of all members of the engineering profession, so it's no wonder that students might have a limited conception of the breadth engineering practice.

Even when it comes to the core of engineering activity that is common to all disciplines, it is well documented that the broader community either doesn't know what engineers do or, worse, holds incorrect views about engineering. A 1998 poll by the American Association of Engineering Societies found that, "61 percent of Americans

reported that they were ‘not very well informed’ or ‘not at all well informed’ about engineering…” (Winsatt, 1998, p. 8). 53 percent of college graduates who responded to the survey reported themselves in the same two categories. Even though a majority of respondents did not understand engineering, the same survey reports that when asked how pleased they would be if a member of their family said they wanted to be an engineer, using a scale of one (extremely displeased) to ten (extremely pleased), the median response was nine; lack of understanding doesn’t equate to lack of respect. Wulf (1998) reports on a 1998 Gallop poll that found, “…only 2 percent of respondents associated engineers with the word ‘invents’…whereas 5 percent associated them with the phrase ‘train operator.’” (p. 23). The situation in the UK is no better; the executive summary of a report by the Royal Academy of Engineering begins, “The central role of engineering in society and the economy is not evident to the public at large nor to the media in particular; the popular perception being generally confined to manufacturing and major building works.” (Malpas, 2000, p. 6).

If the general public don’t have a clear understanding of the engineering profession, it is not surprising that many commencing engineering students do not either. One might expect that commencing students electing engineering as their major study area would know something about their intended career path. While it is true that many students will have investigated their career choice, the participation rate in higher education has risen significantly over the last few decades; to 25 – 30 percent in many countries: US (Pullin, 1999), UK (Dean, 1994) and Australia (Australian Bureau of Statistics, 1999). Consequently, the background, preparation and career understanding of students entering university now spans a much wider range than ever before.

It is clear that an appreciation of the occupational expectations of professional engineering practice is valuable for commencing students. There are a number of strategies

by which students can be introduced/exposed to the nature of professional practice, these include:

- open-ended, real-world engineering problems to solve;
- site visits to engineering workplaces;
- presentations/seminars by practicing engineers; and
- research and analysis of documented case studies of engineering projects.

Commencing engineering classes normally have a large enrolment, making the preparation and/or conduct of some of these exercises difficult or impractical. Sharp (in (Sharp et al., 1999)) reports on a class assignment where students have to:

- use the World Wide Web (Web) to locate a number of engineering job advertisements in their study major;
- analyse the skills, abilities, talents and credentials required by employers; and
- prepare a written report documenting their findings;

and hence draw conclusions about the nature of professional engineering practice. Supplementary benefits of the exercise were identified as developing student skills in the use of the Web, report writing and job-hunting, and increasing student knowledge of the expectations of the employers of engineers. This activity was adapted for use in a first year engineering class at Deakin University in Australia.

A Student Exercise In Exploring Professional Engineering Practice

The School of Engineering and Technology at Deakin University offers a three-year Bachelor of Technology (BTech) and four-year Bachelor of Engineering (BE) at the undergraduate level, in both on- and off-campus delivery modes. As part of undergraduate engineering studies at Deakin University students take a unit entitled SEB121 Fundamentals of Technology Management in the first semester of the first year of their

studies. The enrolment in this unit includes both BE and BTech students, as well as a small number of students not studying engineering-related courses but who take this unit as an elective. This unit is common to all undergraduate programs and covers the following topics: the history of technology and its relevance to society, professional engineering practice, ethics and the professional responsibilities of engineers, library research skills, written and graphical communication, oral presentation, the basic principles of engineering management, and the basic principles of quality. The unit seeks to provide commencing students with foundation skills for the rest of their engineering studies. One of the explicit aims of the unit is to introduce students to aspects of professional engineering practice. One of the means for achieving this is through assignment tasks.

The assignment task described by Sharp (in (Sharp et al., 1999)) was adapted and presented as an assessable task with the following preface, "One way to gain an appreciation of the nature of work that practicing engineers and technologists undertake is to examine the job requirements listed in advertised engineering employment vacancies. This assignment requires you to collect fifteen engineering job ads from the major metropolitan newspaper for employment vacancies in your state or via the Internet." Students were required to identify all of the skills listed as required for the position in each advertisement. After gathering this data students had to prepare a professionally presented written report that graphically summarized their research findings and analysed the range of skills/knowledge areas required by employers. Additionally, to ensure that students reflected upon their discoveries they were asked to respond to the following question, "Has your understanding of what professional engineers do changed since completing this research project? In what way?"

The assignment submissions were received during semester one of 2001 and analysed to extract the following information for each submitting student:

- student gender;
- student study mode – on-campus/off-campus;
- course of study – BTech/BE/Other; and
- an assessment of the student's response to their change in understanding of professional engineering practice – no change/minor change/significant change/not stated.

The results obtained from this analysis are presented and discussed here.

Results And Discussion

Response rate and demographic information

The enrolment in the unit SEB121 was 138 students. 123 student assignment submissions were received, giving a response rate of 89.1 percent. The demographic information of the class population was known, permitting a comparison to the sample group. Table 1 shows the population and sample demographic information, as well as a chi-square goodness-of-fit test comparing the population and sample results. In all cases there was no significant difference between the population and sample demographic characteristics, indicating that the sample group provided a representative sample from which valid inferences about the population could be made. The gender proportions compared closely to the reported overall commencing female participation rate in Australian engineering undergraduate studies of approximately 14.4 percent (Department of Education Training and Youth Affairs, 1999).

[Table 1 about here]

Quantitative results

Based on an assessment of the students' responses to the assignment question, "Has your understanding of what professional engineers do changed since completing this research project? In what way?", each student was categorized as having experienced no change, some change, significant change or no response in their understanding of professional engineering practice. Figure 1 presents the proportion of students in each response category.

[Figure 1 about here]

These results indicate that 86.2 percent of students experienced at least some change in their understanding of professional engineering practice after completing the assignment task. Less than 10 percent of students indicated no change in their understanding of what engineers do. An analysis based on the chi-square test of independence was undertaken to determine if there were different response profiles among the three demographic categories of the sample group, but in all cases no significant difference was observed; Table 2 presents the results.

[Table 2 about here]

Student written responses

To complement the quantitative results above, the students' responses to the assignment question, "Has your understanding of what professional engineers do changed since completing this research project? In what way?", were examined to identify common themes and further explore the students' understanding of professional engineering practice.

In the quotations reproduced below obvious errors of spelling and grammar have been corrected.

Prior to the assignment exercise, some students' understanding of engineering was very limited and/or incorrect, based on common erroneous stereotypes or ignorance:

"Initially I thought that engineering was a field of work that mainly involved manual labour, such things as building roadways, constructing skyscrapers etc. By undertaking this assignment my view of what engineers carry out in the different fields of engineering has changed dramatically. Engineers have more management type jobs than I had originally thought, some involving problem solving type situations, and others like project management e.g. overseeing construction of a bridge…what was most surprising is that most jobs required the use of 'team work'."

"I have to admit I was not entirely sure what engineers actually did once they entered the workforce, and after researching for this project I would have to say that my perception of what engineers do has changed. My major at university is going to be computronics and I knew that it would involve learning about electronics, continuing to be involved in physics and science, but I did not realize that the course would involve so much theory concerning management skills and communication skills."

For some students with prior direct experience of engineers and the engineering process, their understanding of engineering practice was already well developed and, hence, basically unchanged:

"Since completing this research assignment my understanding of what engineers do has not changed. This is due in most part to my engineering background. I am by trade a fully qualified fitter and turner. I have worked in this particular industry for approximately ten years. During which time I was able on many occasions to view the type of work that mechanical and electrical engineers do…The engineer is responsible for the presentation of the entire project."

Even some students with a prior understanding of engineering practice were able to develop their knowledge of professional engineering practice further:

"My understanding of professional engineers hasn't changed much. I always knew that they were situated high in the organization. By undertaking in this research I have gained a clearer understanding that engineers must possess strong leadership and communication skills, as they are responsible to communicate and lead large projects with a large number of employees, whether they be fellow engineers/technologists down to blue-collar workers."

"In general my understanding hasn't changed of what an engineer is. A professional engineer has to be a leader in technology, management and experience. What I didn't realize was how much communication skills were relied upon."

Some students gained an appreciation of the types of skills that might enhance their employability / attractiveness to employers at the completion of their studies:

"Yes, because I did not realize that the engineering field was that diverse, even within Mechanical Engineering. I did not realize that the qualification was the very base from

which to build your career in engineering, which everyone who is going for the job has already got. Experience in the field and leadership can put you in front of others for the job."

"These articles did not change my opinion much about what engineers do, however it did increase my knowledge of what specific qualifications and skills are most important to the employer."

"Analysing these advertisements and looking at the different skills employers want from their future employees, made me realize that a professional engineer needs more than good grades at university to be a reliable and successful engineer in the workforce. Any engineer must be able to communicate with their working environment efficiently and also to be able to work under pressure as well as having the ability to solve problems effectively."

Many students enter engineering studies principally because of a personal interest in working with technology, only to discover that engineering encompasses many other types of activities as well, and that management is likely to play an important part in their longer-term careers in engineering:

"From the information collected I found that engineering involves much more client-based work and projects than I originally thought. I was originally under the impression that engineers were simply given tasks to do rather than dealing with clients and persuading them to get you to work for them."

"After analysis of the requirements that employees want in engineers my understanding of what professional engineers do has changed somewhat. The obvious things such as experience and a degree I was aware of but aspects such as management skills I had never previously thought of."

"…prior to completing this assignment I thought the engineering role was strictly that of design and problem solving. I now realize that while this is a significant part of the job it is but one ingredient. There are many other important aspects involved in undertaking any project, including communicating and generating ideas with other team members, supervising construction/manufacture of the design and taking charge of project time lines and costs."

Some students reported developing a new motivation and focus for their undergraduate studies:

"On completing my research my understanding of professional engineers has changed, as in I now understand that when I complete my degree I can branch out into a minute field that I may find very interesting, this has helped my motivation for continuing this course as it seems terribly broad at this point in time. I know some engineers but it seems quite hard to extract specific information about their particular fields…I now understand some of the skills that I should concentrate on obtaining before I am ready to enter the work force."

Interestingly, one student reported that significant career investigation and planning at the high school level did not lead to clear and complete understanding of engineering practice:

"Before commencing research for this assignment, my opinion of the sort of career and life style an engineer would lead was vastly different. During my last years of secondary education, I had immersed myself in information which I thought related to my preferred course - engineering. I undertook the relevant research into universities and course guides, as well as obtaining some first hand knowledge from engineers themselves. Through this I developed the idea that engineers used their expert scientific and technological knowledge, in a specific field, to design solutions for community problems…Researching advertisements for engineering positions has taken my understanding of the role of professional engineers to a higher level. I found that whilst a sound education was important, it was the level of personal skills, such as communication and management abilities, that determined the degree of success."

Limitations of the study

The assessment task in career understanding described in this paper was not originally designed with a formal evaluation of its effectiveness in mind, hence the inclusion of only a single open-ended question relating to the students' perception of career understanding is a limiting factor in analysing the students' change in career understanding.

The student exercise as described is based on the premise that published job advertisements are a valid reflection of the knowledge and skills actually required in professional practice. While the practise of analysing job advertisements to assess job requirements and the nature of occupational practice is documented in the literature (Cullen, 2000) (Todd & McKeen, 1995), it has been reported that relying on published job vacancy information (such as newspaper advertisements, job notice boards, etc) may not provide intending applicants with a detailed understanding of the actual job requirements

(Breaugh & Starke, 2000). Ultimately though, for many potential employment opportunities, engineering graduates will have to rely on the stated selection criteria given in published job advertisements, so an understanding of the types of published criteria is likely to be of assistance to students in planning their studies and strategically acquiring skills that allow them to match their resume to commonly published job requirements.

Most undergraduate curricula are loaded heavily with content, and this is particularly true of engineering. In a perfect world the exercise as described could be enhanced by the addition into the curriculum of more of the career understanding activities noted previously:

- open-ended, real-world engineering problems to solve;
- site visits to engineering workplaces;
- presentations/seminars by practicing engineers; and
- research and analysis of documented case studies of engineering projects.

However, given the constraints of curriculum space, the cost/benefit ratio of these alternatives and the original aims of the assessment task, the exercise as presented provides an effective and efficient means of achieving the intended aims.

Conclusion

An assessment task requiring students to locate and analyse job advertisements was successfully introduced into a first year / first semester undergraduate engineering study unit to enhance commencing student awareness of the nature of professional engineering practice. An evaluation of the assessment task was undertaken to gauge its effectiveness. A significant majority (86.2 percent) of students reported at least some change in their understanding of professional engineering practice. Less than 10 percent of students reported no change in their understanding of engineering as a career. No significant

difference was observed in these response rates between the three demographic categories (gender, study mode and course of study) of respondents.

Student written comments about how their understanding of professional engineering practice had changed revealed that:

- many commencing students had a very limited or erroneous understanding of engineering professional practice;
- even where students had a good understanding of engineering, many still reported benefits from the exercise in clarifying their understanding;
- some students reported gaining an appreciation of what skills and knowledge were required to enhance their employability;
- many students initially viewed engineering as being focused narrowly on technology and design, and were surprised to discover the diversity of activities undertaken by modern professional engineers; and
- some students reported developing a new motivation and focus for their undergraduate studies arising for a clarified understanding of their intended occupation.

As suggested by the literature, it was found that many commencing engineering students did not have an accurate understanding of the nature of professional engineering practice. The reasons for this are likely to be diverse, but the poor understanding of the engineering profession prevalent in the general population is likely to be a significant factor. Students benefited from, and valued exposure to aspects of professional engineering practice early in their undergraduate studies. The exercise described was a practical and cost-effective method of improving career understanding of commencing engineering students, and also provided an opportunity for students to practice skills in research and report writing.

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Table 1. Comparison of population and sample demographic characteristics.

Characteristic	Population result	Sample result	Goodness-of-fit test
Gender	Male = 85.5 %	Male = 84.6 %	χ^2 (1*df*) = 0.047
	Female = 14.5 %	Female = 15.4 %	$p > 0.82$
Study mode	On-campus = 86.2 %	On-campus = 88.6 %	χ^2 (1*df*) = 0.335
	Off-campus = 13.8 %	Off-campus = 11.4 %	$p > 0.56$
Course of study	BE = 64.5 %	BE = 63.4 %	χ^2 (2*df*) = 0.062
	BTech = 31.2 %	BTech = 32.5 %	$p > 0.96$
	Other = 4.3 %	Other = 4.1 %	

Table 2. Comparison of response profile and sample demographic categories

Response category versus…	Chi-square independence test
Gender	χ^2 (3*df*) = 0.577, *p* > 0.90
Study mode	χ^2 (3*df*) = 0.863, *p* > 0.83
Course of study	χ^2 (6*df*) = 5.315, *p* > 0.50

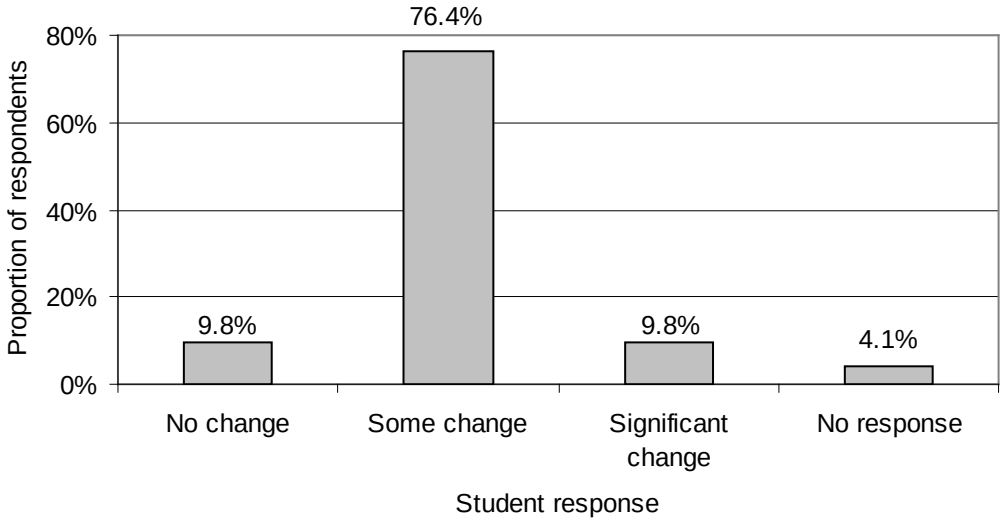

Figure 1. Students' change in their understanding of professional engineering practice