

Would you choose an engineering degree course if given the choice again?

Julie E. Mills, Virginia Mehrrens, Elizabeth Smith & Valerie Adams

University of South Australia, Adelaide, Australia

julie.mills@unisa.edu.au

***Abstract:** The Careers Review of Engineering Women (CREW) was a nationwide survey on career satisfaction and progression conducted by the National Women in Engineering Committee of Engineers Australia in 1999. In 2007, which has been declared the Year of Women in Engineering by Engineers Australia, the CREW survey has been repeated. Some of the questions in the survey were of direct interest to engineering educators, particularly with regard to whether respondents would choose to undertake an engineering degree again or not if they had their time over and why. The number of engineering graduates who have undertaken postgraduate or other further study after their engineering degree and the nature of that study have also been discussed.*

Introduction

In recognition of the fact that women are still chronically under-represented in the engineering profession and that therefore the attraction and retention of women in engineering is both morally and economically important, Engineers Australia has declared 2007 - The Year of Women in Engineering, to raise awareness about the issues of concern to women in the engineering profession, as well as to celebrate their contribution to it.

As part of the program of events, outreach and research undertaken in association with the Year of WIE, the CREW study has been repeated. The Careers Review of Engineering Women (CREW) was a nationwide survey conducted by the National Women in Engineering Committee of Engineers Australia in 1999 (Roberts & Ayre, 2002). The 1999 CREW study indicated that disturbing levels of sexual harassment and discrimination were being experienced by women in the engineering profession, that they were generally less satisfied with their careers and career progression than were men and that they were more likely to leave the profession than men. The initial survey also compared male and female responses to questions about initial employment after graduation, further study and whether respondents would undertake an engineering degree again if they could review their choice. The initial quantitative survey was then followed up in 2002-3 with in-depth interviews of both women and men engineers (41 women, 10 men), which, among other things, asked about their university experiences in engineering (Mills *et al.*, 2006). In 2007 the CREW survey has been repeated and this paper provides an early analysis of some of the data of particular relevance to engineering education and engineering educators, as well as comparing the responses with the previous studies.

Engineering education participation and completion

Higher education statistics in Australia indicate that the percentage of commencing engineering students at bachelor level, who were female, increased from 5.7% in 1983 to 11.7% in 1993, then rose only slowly to a peak of 15.8% in 2001. However, these percentages have since steadily decreased, down to 14.1% in 2005, below the levels of 2000 (DEST, 2000–2006). The percentage of total students completing bachelor level engineering qualifications in Australia who are female is holding steady at around 17.4%, but the percentage of completions amongst female domestic students has decreased over the last three years and this is expected to continue since commencements are trending

downwards. The actual numbers (as opposed to percentage) of females enrolling has plateaued for the last three years, and decreased for Bachelor level enrolments each year since 2003. These figures compare with 19.3% of total undergraduate engineering degree completions who were female in the USA in 2005-6 – the lowest percentage since 1998 (ASEE, 2006). In Canada, the female enrolment in undergraduate engineering degrees decreased from 20.6% in 2001 to 18.5% in 2004 (CCWEST, 2006). The percentage of female graduations in engineering in the UK is even worse than in Australia at 9.5% in 2005/6, and has been decreasing steadily from a peak of 12.2% in 1995/6 (UK Resource Centre for Women in SET, 2006)

Engineering continues to have the lowest female share of any broad field of education in Australian universities with only 15.4% of total student enrolments in 2005 (includes both undergraduate and postgraduate data). The nearest field of education in terms of female participation is Information Technology with 20.2% and Architecture and Building with 40.7% of total student enrolments in 2005 (Lewis, Harris & Cox, 2007).

Total percentage of female enrolment data also masks the fact that the statistics in particular disciplines of engineering can vary markedly. Areas such as chemical and environmental engineering frequently have more than 30% of students being female, whilst fields such as mechanical, electrical and aeronautical frequently fall below 10% and this can often mean in practice that there may be only one female student in any particular class (Lewis, Harris & Cox, 2007)..

The CREW studies of 1999 and 2007 – respondent profiles and retention

The 1999 CREW study was carried out using hard-copy questionnaires mailed to a total of 2269 members of Engineers Australia - 1819 to female members (representing all females at graduate or higher levels of membership at the time), and 450 to male members, matched with the female sample in terms of membership grade, engineering discipline and geographical distribution by state. Responses were received from 767 female engineers (42.2% response rate) and 122 male engineers (27.1%).

The 2007 CREW study was carried out using an on-line questionnaire survey, which respondents accessed following an invitation by email (or by letter to approximately 500 female members who did not have email listed on the database) to a total of 8214 members of Engineers Australia – 3214 to female members (representing all females at graduate or higher levels of membership at the time), and 5000 to male members, matched with the female sample in terms of age, college affiliation and geographical distribution by division. Responses were received from 1,187 female engineers (36.9% response rate) and 605 male engineers (12.1%), so although the response rates were lower, the overall number of respondents was nearly double that of 1999. Figure 1 shows the profile of respondents with respect to age and gender and indicates a well matched sample.

The survey consisted of a total of 93 questions including some text response items. Question categories included base data on gender, age, discipline area and so on; the nature of employment in the last engineering position held; job satisfaction, employment conditions, promotion opportunities and family friendly work practices in the last engineering position held; reasons for leaving the last engineering position and current employment status if not currently employed in engineering and finally, some questions about whether the respondents had experienced sexual harassment, discrimination or bullying during their careers and the nature of it.

Survey results were analysed using the Statistical Package for Social Sciences (SPSS) with cross-tabulations for gender and Pearson Chi-squared tests for significance. For the purposes of this research, a probability level (p-value) of 0.05 was selected, signifying a 95% confidence in the results.

The study found that 95.9% of men were currently working as engineers whilst 4.1 % of men were no longer working as engineers, and 92.7% of women were currently working as engineers whilst significantly more women (7.3%) were no longer working as engineers, ($\chi^2 = 7.0$, $df = 2$, $p = 0.03$). The high participation rate of respondents is not surprising since only current members of Engineers Australia were invited to participate in the survey and it would be likely that people would not retain membership of Engineers Australia if they had left the profession altogether.

In the 2007 survey respondents were asked to indicate the year they graduated from their first engineering degree within a 5 year range (e.g. 2001-2006). Similar to the age profile, this plot indicates that over two thirds (67.6%) of the females have graduated in the last 10 years, with nearly half (45.7%) graduating since 2001. The male graduation profile is similar, but this was a deliberate choice of sample by the researchers so that responses could be compared, whereas for the females this is the actual profile of female engineers, since all female members were surveyed. In 1999 the survey asked respondents to nominate the year they graduated, rather than indicating a range, so the datasets are not easily comparable in this regard.

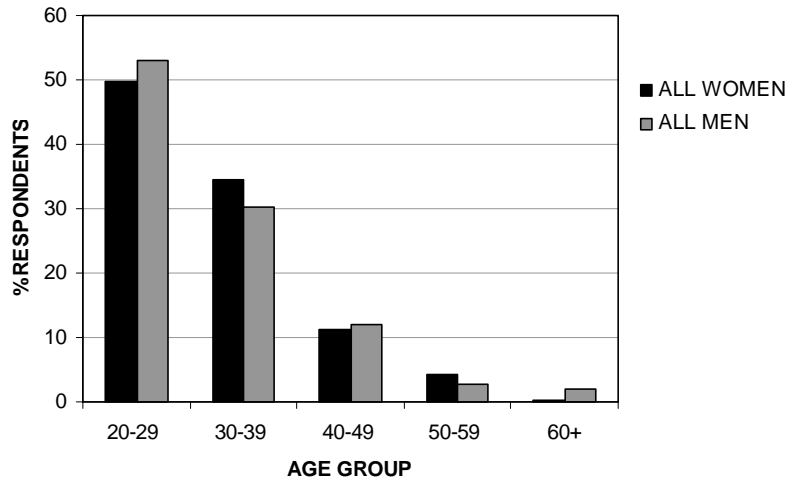


Figure 1 Respondent profile by age and gender, 2007 study

Figure 2 compares the age profile of respondents in 1999 to that in 2007. The disturbing result here is that the plots for women are almost identical, which indirectly indicates that women are leaving Engineers Australia membership, and hence one can reasonably assume the engineering profession. If this was not the case, then if 50% of respondents were aged 20 to 29 in 1999, the proportion in the 30 to 39 age group should have significantly increased in 2007, eight years later, but this is not so. This is also borne out by Engineers Australia membership statistics for the same time period, so those who chose to respond to the survey are not different to the general membership profile. (Engineers Australia, 2007)

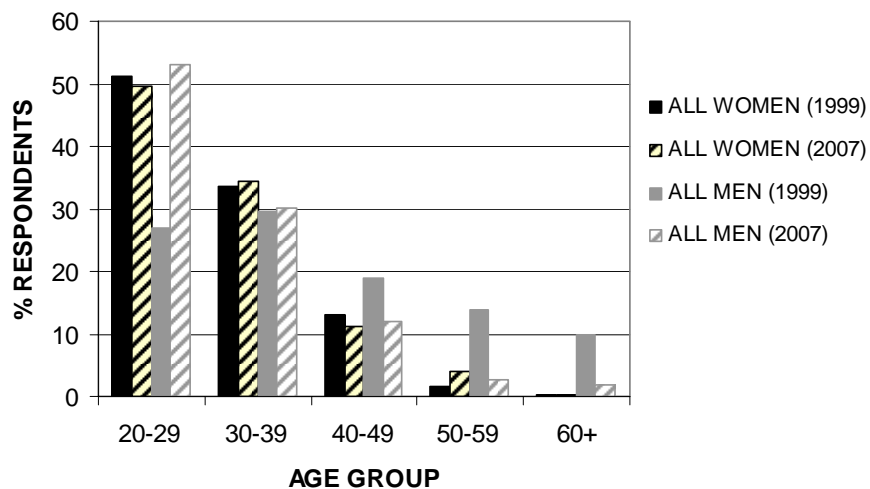


Figure 2 Comparison of age profile of respondents between 1999 and 2007 studies

Employment immediately after graduation

The 1999 CREW study showed little gender difference in the proportions of women and men who begin working as engineers immediately after graduation (85% for women compared with 89% for men). Those who were not working as engineers were approximately evenly divided between unemployment and starting another course related to engineering for both genders.

Surprisingly in the 2007 study when there is a serious skills shortage in engineering, the percentages have changed very little. Female and male engineers joined the engineering workforce in similar proportions after graduation, at 86.1% and 87.3% respectively, slightly closer figures than in 1999. Only 3.4% of women graduates and 3.8% of males were unemployed, 4.0% of women and 2.8% of men had started another course related to engineering and the remainder in each case responded “other”, with text responses primarily indicating that this involved taking time off for travelling or working in a non-engineering position. There were no statistically significant differences between genders in any of these responses.

How many engineers undertake further study and in what areas?

Both the 1999 and 2007 studies showed no significant differences between the engineering qualifications of men and women, with the majority in each survey having a Bachelor’s degree as their highest qualification. However, as indicated in Table 1 below, the percentage with Bachelor’s degrees only has increased slightly since 1999. The high proportion with only a Bachelor’s degree can be partially explained by the young age profile of the survey respondents, but also supports the reality that for many employers a Bachelor’s degree is all that is ever considered necessary for employment in the profession. The increase in this proportion from 1999 to 2007 probably reflects the buoyant job market in the last few years, whereas many of the survey respondents in 1999 would have graduated in the early 1990’s at a time of recession. One of the strategies that was adopted by graduates at that time to increase their employability was postgraduate study, but it could be that this is not considered as necessary in 2007. The postgraduate qualifications in engineering that had been completed were primarily some form of Master’s degree, with only 3% of both male and female respondents having a PhD in engineering.

Table 1: Qualifications by gender

	% Women		% Men	
	1999	2007	1999	2007
Highest Engineering Qualification				
Bachelor degree	76	80.0	72	83.6
Graduate Certificate or Graduate Diploma in Engineering	2	1.9	12	1.7
Master of Engineering	15	13.3	13	9.1
PhD	5	2.8	1	2.8
Other	2	1.9	2	2.8
Post-graduate qualifications (NOT engineering)				
	2	16.4	1	17.7

Respondents were also asked whether they had any other postgraduate qualifications that had been completed outside of engineering. In the 1999 survey only 2.4% of women and 0.9% of men indicated that they had any other postgraduate qualification and these were primarily Master of Business Administration (MBA). There was a marked increase in post-graduate qualifications in areas other than engineering reported in the 2007 survey. In total, 16.4% of women and 17.7 % of men engineers had qualifications that ranged across PhD, Masters, graduate diplomas and graduate certificate

courses. However, some respondents ignored the postgraduate description and listed second bachelor degrees in their response – usually in commerce or management, which were probably obtained through a double degree arrangement. This accounted for 1.2% of the responses to this question in 2007. Of those that described postgraduate qualifications, these ranged across a wide spectrum of studies with business administration, project management, environmental studies, law, applied science and education being popular choices. These results indicate that engineering faculties may need to consider management and multi-disciplinary postgraduate qualifications along with traditional engineering based programs in their program portfolios, if they wish to attract today’s engineering graduates back to postgraduate study.

Would you choose to study engineering again?

One of the last questions in the survey was “Would you choose an engineering degree course if given the choice again?” The responses for both 1999 and 2007 are plotted in Table 2. There were no statistically significant differences in the male and female responses to this question. The decrease in “no response” rates is almost certainly attributable to the electronic nature of the survey in 2007 compared with paper in 1999. The decrease in percentages of people who would not take an engineering degree again between 1999 and 2007 is encouraging, but may again be attributable to the buoyant employment situation for engineers in 2007.

Table 2: Would you choose to study engineering again?

	% Women		% Men	
	1999	2007	1999	2007
Yes	54	75.8	64	77.2
No	26	19.0	24	16.4
No response	20	5.2	12	6.4

The reasons given for not choosing an engineering degree again are enlightening and need to be considered seriously both by engineering educators and the profession as a whole. Both men and women commented consistently about the lack of recognition of the engineering profession and also the lack of reward for the levels of responsibility and time commitment expected in an engineering role.

“I would find a profession that gave better recognition and salary. Engineering has absolutely no status and any Tom Dick or Harry can call themselves an Engineer. Not just anyone can call themselves a Doctor so why is the name not protected?” (Female, 40-49 age group)

“Not a well rewarded and respected profession. Do not receive the same recognition as other countries.” (Male, 20-29 age group)

“The public do not appreciate or reward engineers commensurate to the level of skill and dedication required. My communication skills would be more suited to other fields.” (Female, 20-29 age group)

Both genders also specifically commented on the lack of financial reward in engineering but these comments were more prevalent amongst male respondents than females. Many males also specifically compared their situation with that of university friends in fields such as commerce, and also friends in trades.

“As we are under paid for the responsibility that is required of us, yet we are required to work long hours with little reward.” (Male, 30-39 age group)

“Difficulty of study not worth monetary rewards in comparison to other fields.” (Female, 30-39 age group)

“Engineering profession is not as highly regarded or as highly paid as other professions, felt like I worked harder than a lot of other students at uni, but friends who studied commerce and are

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now working in finance are earning much more than me - and I used to teach them maths!”
(Male, 30-39 age group)

Some also added comments about the profession not being technically challenging enough.

“Insufficient rewards. Insufficient recognition. Not challenging enough - sure it is busy enough and stressful enough but not creativity challenge-wise Antiquated culture compared to other industries.” (Male, 30-39 age group)

Very few males commented on issues related to family and work-life balance.

“The pressure of work hours is too high to maintain a proper family life as well at a number of intervals through the year.” (Male, 30-39 age group)

However, this was a very commonly expressed reason provided by women across all age groups as to why they would not undertake engineering study again.

“I might but then I would not have children. Having had children it has been impossible to establish a career in engineering. I wish I had studied for a career that fits better with family responsibilities.” (Female, 30-39 age group)

“Because a career as an engineer is limited if you are a woman. Few companies offer part time work, so it is difficult to combine children and a career. Also work hours are too hours long.”
(Female, 20-29 age group)

The prevalence of work-family issues for women respondents and their absence for male respondents confirms that not only is the engineering workplace culture female and family unfriendly but that this characteristic is not noticed by male engineers in that workplace, either for themselves or for their female colleagues.

Other issues of importance to engineering educators

One of the most disturbing findings of the 1999 CREW study was that 36% of all women reported that they had experienced discrimination while working as engineers, and 27% reported that they had been sexually harassed. The 2007 study also surveyed these aspects and in addition respondents were asked to report if they had experienced bullying. In 2007, 42.3% of women reported that they had experienced discrimination while working as engineers, 22.0% reported that they had been sexually harassed and 28.2% had experienced bullying. It is pleasing that the reported incidence of sexual harassment has decreased (although 22% is still unacceptably high), but very disappointing that reported discrimination has actually increased since 1999. Respondents were then asked to categorise the nature of the discrimination and the overwhelming response from women was that it was based on gender. By comparison, 15.8% of men reported that they had experienced discrimination while working as engineers, 2.8% reported that they had been sexually harassed and 18.6% had experienced bullying.

Respondents were asked to describe their experiences of discrimination and harassment and their comments indicated that both discrimination and sexual harassment remain as ongoing issues for them. This was consistently reported across all age groups.

“Despite 25+ years of working in the profession, I still face discrimination and skepticism of whether I can do the job.” (Female, 50-59 age group)

“The industry that I am working in is very male dominated. There are many views that females do not belong in the industry. Some state that females are too emotional and there's no room for it in engineering.” (Female, 20-29 age group)

These reported incidences related to respondents' experiences in the engineering workplace, however they also have clearly important implications for engineering educators. Many studies have shown that women also experience problems of discrimination and harassment during their time of studying engineering at university (e.g. McLean *et al.*, 1997), and although these issues may be less overt and less frequent at university in recent years, engineering educators should not think that they don't exist at all.

Conclusion

The 2007 survey showed a marked increase in respondents reporting completion of non-engineering post-graduate qualifications compared with 1999, that ranged across PhD, masters, graduate diplomas and graduate certificate courses. The most striking aspect of these was that, unlike the 1999 survey which showed non-engineering post graduate studies to be predominantly MBA's, the studies reported in 2007 ranged across a wide spectrum of disciplines. This has implications for engineering faculties wanting to attract post graduates in that it signals a demand for management and multi-disciplinary programs, rather than only traditional engineering based programs. While the majority of respondents were satisfied with their choice of an engineering degree, a significant proportion of them were not. Text responses from the 2007 survey indicate that the main reasons that they would not choose to do engineering again were lack of recognition for both men and women engineers; lack of reward for the levels of responsibility, which was more prevalent among female engineers; and issues related to work-family life balance which were a major problem for women rather than men engineers. The gendered nature of this problem signals a need for change in the workplace culture of engineering firms.

Engineering educators have an important role to play in helping to reduce the incidence of harassment and discrimination against women in the engineering workplace by contributing to the process of cultural change through education of those who are about to enter those workplaces. An appropriate engineering education should involve both male and female students in discussion and analysis of the social and political dimensions of the typical engineering workplace, including a statistical breakdown of current participation in engineering and an argument about the benefits of working for increasing diversity which better reflects developments in the Australian population as a whole. Such courses should also provide students with an array of strategies for participating within engineering workplaces without either perpetuating or needing to conform to the stereotypical roles currently available. This type of professional education would ensure that young skilled people do not enter the workplace as technically competent but naïve players in a world constrained by gendered world views and practices, and thus better prepare the future generations of young professionals to work together to change some of the existing outdated cultures.

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