

WOMEN ENGINEERS IN TERTIARY EDUCATION IN AUSTRALIA: THE STRUCTURAL AND CULTURAL BARRIERS THEY FACE

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Women form only a small minority of undergraduates, postgraduates and academics in Australian engineering faculties. In 1993 women represented 14 percent of those commencing bachelor degrees in engineering at universities, 15 per cent of those commencing research masters degrees and 13 percent of those commencing doctorates.

In 1994 less than 6 percent of engineering academics were women. These women were heavily concentrated in the 'below lecturer' grades and in limited tenure positions. In 1994 they held 16 percent of the below lecturer positions but less than 4 percent of the tenured/tenurable positions. These differences are only partially explained by differences in age distribution.

In this paper the structural and cultural difficulties which face female engineers within tertiary education in Australia are analysed. The impact that the lack of women in engineering faculties may have on factors such as student workload, and course content and delivery are discussed.

1. INTRODUCTION

There are two main parts to this paper. One, which is purely statistical, documents the number of female students and academics in engineering in Australia in recent years. This shows that the females are a small but growing minority. The second is a discussion of how this imbalance between males and females may affect cultural aspects within engineering education. Because the numbers of women are so few and there are no engineering departments or disciplines where women form anything but a small minority there is no objective way of knowing what a 'feminised' engineering might be like. This discussion is therefore based principally on my own opinions developed over 25 years spent in a combination of work and study in five different universities: two in Scotland and three in Australia. Where possible I have supported my opinions with the experiences of some other women engineering academics and from indirect information about other disciplines.

Over the years there have been a number of issues such as student workload and the correct balance between research and teaching where I have found my views to be at odds with those of many of my male colleagues. It is only in the last few years that I have had the opportunity of meeting a number of other women engineering academics and of reading the growing literature on women academics in general. It has been reassuring to discover that my views rather than being those of an 'aberrant' engineer may be those of a normal woman.

2. FEMALE UNDERGRADUATE ENGINEERING STUDENTS IN AUSTRALIA

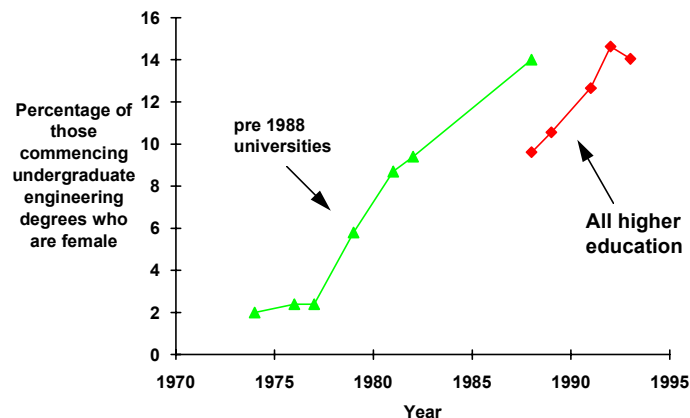


Figure 1. Percentage of those commencing undergraduate engineering degrees in Australia who are female.

Figure 1 shows how the percentage of those commencing undergraduate engineering degrees in Australia who are female. Before 1988, the tertiary sector in Australia was divided into universities and Institutes of Higher Education. The graph shows only the university enrolments for the period 1974 to 1988. In 1988 the two sectors merged and since then statistics have been available for all of higher education. (ABS, 1982: DEET 1988-1993). A more detailed breakdown of the pre-1988 statistics is given in Armstrong (Armstrong 1990) The graph shows that until the late seventies women formed only a tiny minority of engineering students. The percentage of women climbed steadily through the eighties and early nineties so that now women form a still small but now significant minority.

The seventies, eighties and nineties have also seen a marked change in the culture of engineering undergraduate courses. To take the example of Melbourne University, the seventies were the heyday of the Engineering Society and SCIIAES (the Society for the Containment of Immoral Impulses among Engineering Students). The Engineering Society ran frequent beer drinking sessions. Second year students attended first year lectures to 'educate' first year students how to make paper darts and disrupt lectures. Unpopular lecturers were deluged with paper darts.

Over the eighties and nineties the atmosphere in engineering lecture rooms has changed to one more serious. Disruption is now more likely to be in the form of persistent chatter. There are a number of factors which have probably contributed to these changes. These include the threat of unemployment, the increasing numbers of overseas students and the introduction of HECS. However I believe that the change is due at least in part to the increasing proportion of female students. In the seventies and eighties female students often told me of their impatience with what they saw as the immature behaviour of some of the male students.

Undergraduate life has improved significantly from the perspective of the individual female engineering student. Nowadays although the percentage is still small the isolation is not so extreme. Most female students would have a number of others in their classes. Many engineering faculties have Women in Engineering programmes (Harris and Learmont, 1992) to encourage school girls to consider engineering as a career and to offer support to the female students within their courses. However, as I will explain later, I believe that there are still many aspects in the structure and teaching of engineering courses which conflict with the values held by many women and which act to discourage female students.

3. FEMALE POSTGRADUATE ENGINEERING STUDENTS IN AUSTRALIA

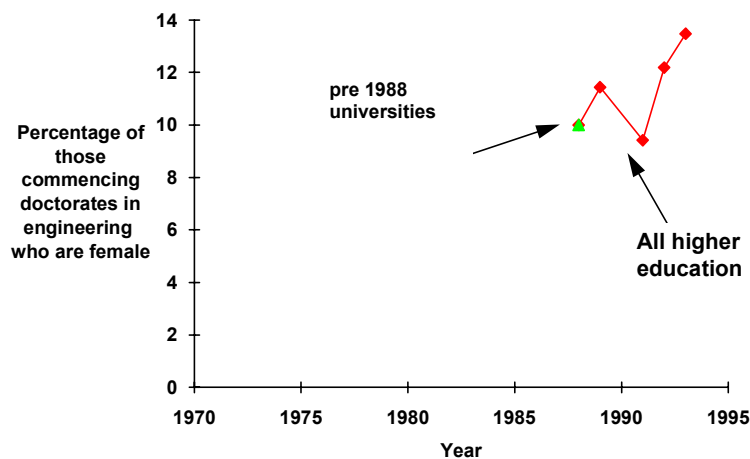


Figure 2. Percentage of those commencing doctorates in engineering in Australia who are female.

Figure 2 shows how the percentage of those commencing doctorates in engineering who are female. It is interesting to note that the percentage of females commencing doctorates is almost as high as the percentage commencing bachelor degrees. (Results are not presented for the period before 1988 as the numbers are so small, less than 10 females commencing and less than 100 males commencing doctorates each year.) In most other disciplines, including those such as arts where women form the majority of undergraduates, a smaller proportion of women than men continue to postgraduate work. The engineering figures are even more surprising as one would expect the numbers of women commencing postgraduate work in 1992 to reflect the smaller number of women who commenced undergraduate degrees in 1988 or earlier. There are a number of possible

reasons for this apparently high retention rate (Armstrong, 1990): Many female engineering students 'star' as undergraduates and may therefore be more likely to proceed to postgraduate study. Some of those undertaking doctorates in engineering have undergraduate degrees in other disciplines. More women may change universities in the course of their studies and therefore commence more than once. Many postgraduates, including female postgraduates, are overseas students.

Because of the relatively smaller numbers of postgraduates, women postgraduates in engineering are likely to be the only, or one of very few female postgraduate in their department. Interviews with women postgraduates at Melbourne University in 1990 (Armstrong 1990) showed that for this small sample at least, women postgraduates in engineering had many of the same characteristics as have been found in women postgraduates in general. They are often mature age students with small children, they lack confidence, they experience dissatisfaction with their supervisors and have feelings of isolation.

Women in general are disadvantaged by the rules regarding part-time postgraduate scholarships and taxation. Part-time scholarships are taxed, whereas full-time scholarships are untaxed. The real value of part-time scholarships can therefore be much less than half that of a full-time scholarship. Although the situation regarding availability of part-time scholarships has improved somewhat over the last few years, some scholarships such as the APRA(I) which are often held in engineering disciplines are not available on a part-time basis.

4. WOMEN ENGINEERING ACADEMICS IN AUSTRALIA

Women academics in Engineering in Australia in any numbers are a relatively recent phenomena. Over (Over 1981) reported that in 1980 there was only one (the author of this paper) female engineering academic of lecturer level or above in Australian universities. My isolation was not however complete as there were other women working in the same institution as lecturers but who were classified only as tutors and there were probably other tutors in other universities and lecturers in Institutes of Higher Education who were not included in Over's statistics. The graphs below show how the number of women academics has grown in the last few years.

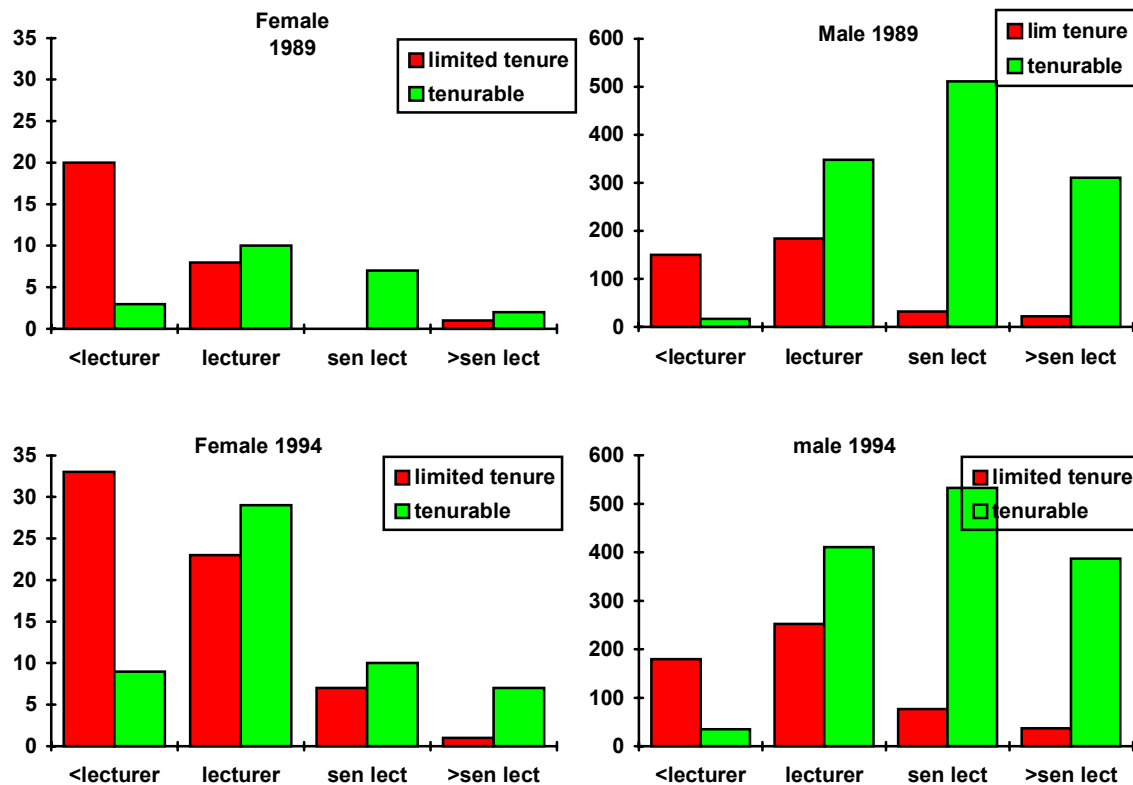


Figure 3. Number of male and female academic staff in engineering/processing employed in Australian universities, by level of appointment and tenure. (Note change in scale between graphs for male and female).

The information given in Figures 3 was obtained directly from the Department of Employment, Education and Training (DEET) in Canberra. The classification of academic staff includes both research and teaching staff. The statistics are for the discipline 'engineering/processing'. Statistics in this form are only available from 1989.

In 1989 there were only 52 female academic staff in engineering/processing in the whole of Australia. This represented 3% of the total. By 1994 the number of women had more than doubled to 125 which was almost 6%. Women were concentrated in the lower grades. Only 44% of them held tenurable positions compared with 69% of men. The category with the greatest number of women was 'limited tenure, below lecturer'. While for men the most common category was 'tenurable senior lecturer'. There is some anecdotal evidence that the statistics may over represent the real number of women. For example one university, for which the statistics quoted 10 women, had in reality far fewer than this and several of these were on part-time appointments.

The female academics were on average younger than the males but this difference alone does not explain the difference in grades. For every age band, from the youngest to the oldest, the females were on average in lower grades than the males.

In a paper on Women Engineering Academics in Australia, Armstrong and Bellis (Armstrong and Bellis 1993) discuss factors which may disadvantage women academics such as family responsibilities, reduced mobility compared with male academics, the role of research, teaching and administration in appointments and promotions, lack of career planning, lack of mentors and networking and direct discrimination and prejudice. American studies have shown that women academics on average spend significantly more time in scheduled teaching and preparation of teaching. A similar situation arises for administration and counselling. The author's personal experience suggests that women in engineering faculties are very likely to take on these roles. Roles which are not adequately rewarded in terms of promotion and tenure. The disadvantage of this to women in engineering may well be greater than in other faculties: first because there are so few women that there are few to share the burden and an individual is therefore very likely to take on a major role of this kind, and secondly because the culture of engineering faculties is so masculine that these roles may be rated even lower than in other faculties.

5. COURSE CONTENT, PRESENTATION AND ASSESSMENT

Over the years I have frequently had the experience of holding views very different from the majority of my male colleagues. It is only in recent years when that I have been able to discuss these issues with other women engineering lecturers that I have found that these views are shared by many other women. In the following I discuss some of these issues, present some data which suggests that these are indeed gender issues and hypothesise about what a 'feminised' engineering course might be like.

5.1 Student Workload

One matter on where my views differ is on the issue of student workloads. Many engineering academics express the belief that engineering students should devote many hours to study. In one recent example it was recommended that the official workload should be 48 hours per week (24 contact hours and 24 hours of private study) and that a forty hour week was to be considered a 'minimum effort'. In the past I have even heard figures like 60 and 70 hours mentioned as what should be expected of students. I believe that this attitude ignores the realities of student life in the nineteen nineties which usually involves at least one of the following: part-time work, long travelling time, family responsibilities and domestic duties. It also demonstrates values different from my own and I believe many other women. The long hours seem to be regarded as a virtue in themselves not as a necessary evil which they believe is required to become an engineer. 'Soft' courses such as Arts with far fewer contact hours are often mentioned with scorn. Most women I would suggest would prefer a more balanced life in which time can be devoted to other interests and responsibilities.

Most engineering courses I believe are overloaded with content. This I contend is partly as a result of this belief in long study hours as a virtue in themselves.. Not enough effort is put into trying to identify what really are essential skills and knowledge and trying to use the students' time to achieve these results most efficiently.

It is impossible to prove directly that more women staff would result in engineering courses that are less overloaded. However an analysis of the results given in the reports published each year by the Graduate Careers Council of Australia (Long, 1994) shows a relationship between the percentage of female students in a field of study and the rating that the field of study receives on the appropriate workload scale.

Each year the Council distributes a 'Course Experience Questionnaire' to students who have just completed university courses. The survey includes most Australian Universities. The questionnaire includes a range of questions concerning the students' experience of their courses. The questions are grouped to give results on a number of scales: the Good Teaching Scale, the Clear Goals and Standards Scale, the Appropriate Workload Scale, the Generic Skills Scale. One item, the Overall Satisfaction Item was not grouped with any others.

The students' fields of study are grouped into major and minor classifications. 'Engineering, Surveying' is a major classification. Civil/Structural Engineering, Electrical Engineering and Mechanical Engineering are the three minor classifications within the Engineering/Surveying major field for which results are listed in the report on 1992 graduates. In 1992 Engineering/Surveying students gave slightly lower ratings than the average for all students on the Overall Satisfaction Item, the Clear Goals and Standards Scale, and the Appropriate Assessment Scale. They gave a slightly higher than average rating on the Generic Skills Scale. However the ratings on the Good Teaching Scale were worse for Engineering/Surveying than for all but one other major field of study and for Appropriate Workload Scale it was rated worst of all. When minor fields of study were considered, Electrical Engineering was rated the worst of any minor field of study on the Good Teaching Scale and second worst on the Appropriate Workload Scale. To test the hypothesis that excessive workload might be associated with the 'maleness' of the discipline, I graphed the ranking for the Appropriate Workload Scale against the percentage of women students in the field of study. The results are shown in Figure 6. Note that each point is the average for all of the students in that discipline Australia wide and not for an individual university or department.

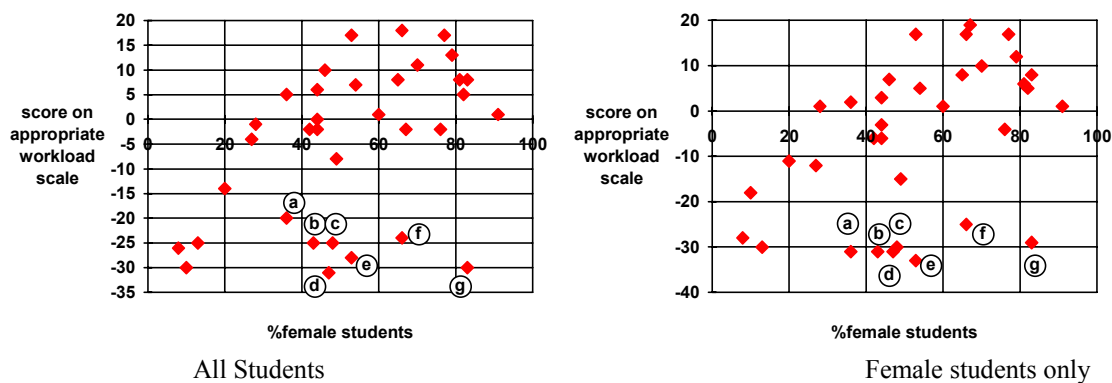


Figure 6 Score on Appropriate Workload Scale versus % female students for the minor field of study classifications given in the results of the 1992 Course Experience Questionnaire.

Figure 6 shows a clear trend. Apart from the points for those fields of studies which are individually labelled, the more female students in a subject the subject the better the rating on the appropriate workload scale. This is true both when the scores for all students, and for female only students, are considered. In other words both males and females in the more 'masculine' courses give low ratings on the appropriate workload scale. It is interesting to identify the fields of study which do not follow the trend. They are (a) building (b) medicine (c) architecture (d) dentistry (e) veterinary science, (f) pharmacy and (g) rehabilitation. All, or most, of these disciplines would have had very low female enrolments until very recently.

There are also a number of other ways of interpreting the trend. Female students may be choosing the soft options. Some of the subjects with heavy workloads are professional courses. It could be argued that workloads must be heavy so that graduates have the knowledge required to practice in their profession. The report itself suggests that the courses with low scores are also ones with strict entry requirements and that perhaps the students in these courses are more critical. Another argument might be that there is nothing wrong with a heavy workload, but the authors of the report interpret high scores on this scale as indicating an appropriate workload and low scores as workloads which are so high as to interfere with student learning and force them to adopt an approach to learning which emphasises skimming across the surface of topics.

To explore further any possible relationship between the maleness of a discipline and its rating on the Appropriate Workload Scale, I compared statistics of the percentage of female academics in a discipline with the results on the Appropriate Workload Scale.

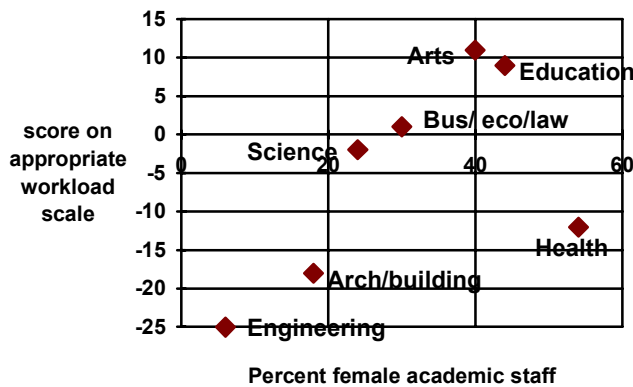


Figure 7 Score on Appropriate Workload Scale versus percentage female staff

Figure 7 graphs the results on the workload survey for major fields of study against figures obtained from DEET for the percentage of female staff. The figures should be treated with extreme caution. The groupings of field of study may not match exactly in some cases, for example the closest match to the grouping 'architecture/building' in the graduate questionnaire is 'built/ environ' in the DEET figures. Arts, Humanities and Social Sciences is matched with Humanities plus Social Studies. However the results seem to follow a trend: the more feminised the discipline the higher the rating on the appropriate workload scale. The one anomaly is the point labelled 'health'. This major field of study consists of the minor fields of study, dentistry, medicine, nursing, pharmacy and rehabilitation. The overall score of -12 is the result of scores of -31 dentistry, -25 medicine, 1 nursing, -24 pharmacy, -30 rehabilitation. As presumably nursing has a much higher percentage of female staff than the others this confirms rather than denies the trend.

5.2 Course Content, Course Presentation and Assessment

Another aspect which I believe would change dramatically if there were a greater female influence in engineering is the course content. This would change in both a broad sense: a wider range of subjects from other disciplines would be allowed as part of the degree, and a narrow sense: individual technical subjects would have an approach which would include more attention to social, political and ethical aspects. Joint degrees such as Arts/Engineering and Law/Engineering which allow a wider range of study have much higher female enrolments than straight engineering showing that females are indeed more likely to study engineering if they can at the same time study subjects in other disciplines.

One notable aspect of recent Australasian Association for Engineering Education conferences has been the number of women presenting papers on topics such as ethics in engineering, the use of problem based learning in engineering, cross disciplinary courses involving engineering. Given the small total numbers of women academics, this suggests that women academics in engineering are more interested, or rate as more important, these aspects.

Typically engineering courses rely very heavily on a traditional mix of lectures, tutorials and laboratories. The learning is very directed. The one common exception is the final year project. It is interesting how the few women engineering academics that there are, have been very prominent in introducing other modes of learning which involve more open ended assignments and more student control of the learning process. Interestingly, analysis of the results of the Course Experience Questionnaire shows a relationship between the Good Teaching Scale and the femaleness of the discipline.

Assessment in engineering courses usually depends heavily in formal examinations. A form of assessment which may disadvantage female students. (Armstrong and Leder 1995) . Even within these examinations writing skills are usually weighted very lowly. I am unusual in adopting a policy of deducting marks for grammar and writing so poor that they make the meaning of the answer unclear. Often examinations test retention of facts rather than basic understanding. I suggest that a more feminised engineering would have a much wider range of assessment measures which I believe would match more closely the skills required by the working engineer.

6. CONCLUSIONS

Females still form a small minority of undergraduates, postgraduates and academics in Tertiary Engineering education in Australia. The author believes that if the percentage of females was to increase significantly the culture of engineering departments and the content, presentation and assessment of undergraduate courses would change. Courses would have less content but would include a wider range of material. Courses would be presented in different ways and student oriented approaches including problem based learning would be used more often. A wider range of assessment measures which demanded greater written and verbal skills would be used.

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