Female Engineering Students:
Career Motivation and Their Learning Experience

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Abstract: Engineering has remained one of the most male dominated professions across the globe and it is not until the latter half of the 20th century that engineering started opening its doors to women. The enrolments of female students in the Faculty of Engineering at the University of Sydney have been on a slow but steady rise over the last ten years, however, female engineering students form only about 17% of the total student population in the engineering faculty. This study is a part of a research project conducted at the Faculty of Engineering, in the University of Sydney, with about 250 engineering students, in order to highlight the learning experiences of the undergraduate female engineering students. It analyses the educational background of female engineering students and how this motivates them to choose engineering; furthermore it investigates their learning experiences in a male dominated faculty with an aim of identifying key issues that need to be addressed in order to improve the learning environment of female students, and to attract more female students to engineering.

1. INTRODUCTION

In the last two decades there has been a large number of studies that have been conducted on women in engineering; which has resulted in an astronomical number of books, journals and papers. [1][2][3][4][5]. These papers have some major themes in common: the work of women in a male dominated profession, gender harassment in the workplace, recognition of women's work in engineering and their career progression and the attrition rates of women in engineering but to name a few. A recent study by Beraud gave the possible reasons why the number of women in Engineering is increasing too slowly [6].

Interesting to note though, not as much research has gone into the study of female engineering students the ones who grow up to be the women in engineering. Therefore this research is based solely on undergraduate female engineering students. As a prelude to the study on their university life, a part of the research also explores the learning backgrounds of the female students on their path to engineering

2. NATURE OF THE RESEARCH

250 undergraduate engineering students participated in this research. This group consisted of 150 male engineering students and 100 female engineering students. The students were randomly selected across all disciplines of engineering regardless of their year of study. The methods used for data collection were questionnaires and in-depth interviews. All 250 students have filled in questionnaires amount them 30 female students have participated in-depth interviews.

This report will summarise the overall findings of the survey and provide some descriptive explanations for some of the results obtained. This survey was both quantitative and qualitative. The figures used are in percentages. The questionnaires facilitated the quantitative analysis of the response of both groups (female engineering students and male engineering students) to the research. The in-depth interviews were used to elicit responses from female engineering students on issues concerning their educational background, their career motivation their learning experiences and their suggested recommendations on how the faculty could help create a better learning environment for them. In summary the main objectives of the research were;

- To investigate the learning background of the students that participated in the research, and its role in influencing their choice to do engineering
- To investigate how well the female engineering students were coping with their workload as compared to the male engineering students
- To determine the future career aspirations of the students
- To if determine if there were any cases of both gender harassment.

3. THE PATH TO ENGINEERING

Although many people still view engineering as a male profession, last year, the faculty of Engineering at the University of Sydney enrolled 441 undergraduate female students, which is 16.84% of the total student population [7]. What is it about these girls that set them apart from the rest? When asked about their choice to do engineering the female engineering students gave a number of reasons most of which were tied to their cultural and educational background the following discussion evaluates this more closely.

3.1 Why engineering?

When interviewed the female engineering students gave the following four main reasons for choosing engineering.

- Excellence in Mathematics and Physics
- Influence from parents, friends and teachers
- The presence of an engineer in the family.
- For the challenge of doing the course.

3.1.1 Excellence in Mathematics and Physics

90% of the female students interviewed cited their mathematical ability as the main reason why they chose to do engineering. Most of these students did not even think about doing engineering until after high school when they obtained their Higher School Certificate (HSC) results. A few admitted to not knowing much about engineering and just picking it out of the fact that they had done so well in their sciences. Only about 10% of the female students interviewed said that throughout their childhood, they had always wanted to do engineering. Similar studies have shown that excellence in mathematics and physics is one of the most fundamental reasons why girls choose engineering. [16] [17] [5]. As a prerequisite, engineering courses require high scores in mathematics and science and these girls are able to meet this easily. However after further research it became apparent that this is not all that the female engineering students needed to successfully complete their engineering courses this issue will be revisited in Section 4.

3.1.2 Influence from Parents friends and teachers

When asked which people were important on influencing their choice to do engineering, almost all the female engineering students cited their parents, friends and their science teachers. As one student put it:

> *"I always wanted to be a teacher but my mother advised me to take up engineering due to my high scores in the sciences. I still think I should have taken teaching because I prefer dealing with people to dealing with machines"*

Similar research studies have shown that influence from parents, and career advisers are also one of the reasons that girls choose engineering. [16]. These people have the power to influence these girls' career choice because they are able to recognise their special talents in their science subjects and push them towards a career where they can utilize their special talents.

3.1.3 Presence of an engineer in the family

50% of the female students interviewed had an engineer in the family. A few of them had a female engineer in the family and they admitted that the presence of the female engineer made them decide to take up engineering. As one student put it:

> *"After my Auntie who is an electrical engineer found out about my HSC results, she pushed me to take up engineering"*

On the other hand those who had a male engineer in the family said that although the presence of the male engineer did not really influence their choice to do engineering, but these male relatives supported their decision to become engineers. The female engineers within the family in this case served as role models for the girls. Previous research has shown that the presence of a role model or lack of; is one of the main reasons that will influence female students to take engineering or in their absence influence them not to choose engineering. [5]

3.1.4 For the challenge

There was a different group of female students interviewed that admitted to having taken up engineering out of the sheer challenge of wanting to test waters that many of their female peers had not (6.6%). As one of them said:

> *"My high school friends said that a girl could not do engineering. I wanted to prove them wrong; therefore I decided to do engineering. I am in my fourth year now but I don't intend to practice engineering. I find it boring."*

These female students were good at mathematics but more than anything the thrill of taking up a "predominantly" male course was irresistible. They loved a challenge and they were not afraid. The female students who belonged to this group were of strong a character and outspoken. For them the end was the reward.

3.2 An unnatural path.

In her book *"Women in engineering: gender, power, and workplace culture"* McIIwee describes the path to engineering for most women as not so smooth. [5]. McIIwee goes further to explain that: unlike their male counterparts whose choice follows naturally from their love for tinkering machinery and technology as children; for women their choice of engineering is a result of a combination of gender roles and academic skills. Following our own research we observe that the path to engineering was almost unnatural for most of the female students interviewed. They showed no real interest in tinkering as children nor technology but their high scores in mathematics and physics coupled with a changing culture that now requires women to take up professions that may be equally demanding as those taken by men, propelled them to take up engineering.

4. THE MAJOR THEMES IDENTIFIED FROM THE RESEARCH

The major part of the research involved comparing and contrasting the learning experiences of both the male and female engineering students. The students view on their workload, their tutors as well as their participation in extracurricular activities were compared and contrasted based on gender. The objective here was to be able to observe the similarities between the learning experiences of both groups as well as to identify the main problem areas within the system and make suggestions on what the faculty could do to alleviate or better still eliminate these problems. The list below shows a summary of the major themes from the research.

1. Both male engineering students and female engineering students found their workload heavy (80% female, 64% male), despite the fact that most of them were enrolled in what the faculty termed as a normal semester workload.

2. Almost half of the students that participated in the research did not participate in extra-curricular activities most cited the lack of time due to study demands as the main reason. This was true for both the male engineering students and the female engineering students.

3. A fair percentage of the female students that participated in the research complained of having experienced some form of gender harassment within the faculty. Gender harassment within the faculty was mainly defined through two aspects; group socialization and special treatment of the minority group i.e. female engineering students.

4. A shocking majority of the female students (70%) admitted that at some point or other during their time at the university they had reconsidered their career choice. The main reason cited by most of them was that the course was too demanding and leaving them with little if any time for extra curricular activities. About 50% of the male students admitted that they too had had second thoughts about choosing engineering but majority of the said that this was because they found the course boring.

5. Although majority of the female students had had second thoughts about choosing engineering, 72% of them intended to pursue engineering after graduation as compared to 66% of the male students.

4.1 Workload

As stated, most of the students rated their workload as heavy with the female students on a higher percentage (80% as compared to 64% of the male students). One of the main reasons given by the female students was that they spent almost all their spare time trying to finish their assignments and keep up with their class work such that there was hardly any time left for them to review the material they had covered during their lectures. Usually this had to be left off until when they attended their tutorial sessions, where they would have a short time to review the material. As a student put it:

> *"The course is too demanding. The workload is overwhelming. I don't fell like I retain much of what I learn. I just cram to get through the exams."*

Conclusively, the male students seemed to be handling their workload better but this is not to say that they were performing better.

The best preferred mode of learning was tutorial sessions, which was true, for both groups of students (72% female, 42%male). However, more female students preferred tutorial session than male students. When interviewed the female students said that they felt this groups were smaller and hence more personal as compared to their lecture sessions, which gave them a chance to compare material with other students as well as ask questions.

Only about 6% of the female students found their laboratory sessions useful. There was a general feeling of insecurity about the laboratory sessions among the female students that were interviewed. More than half of the female students said that on most occasions they felt that they did not really know the material covered during the sessions and that sometimes they failed to see how this connected with their lecture material. Additionally they felt that the time allocated for these classes was too short. As one student put it:

> "S*ometimes I stand there not knowing what is going on. I felt that there is a bt of assumed knowledge when it comes to the labs and I feel incompetent in that respect"*.

This brings us to reflect on the previous section, which dealt with the girl child on her path to engineering. As a conclusion we observed an almost unnatural path to engineering for most of these female engineering students and a lack of childhood interest in tinkering, machines and technology. This explains the feelings of insecurity that the female students experience with their practical sessions, which take them beyond the theoretical process of learning (which they have

learnt to excel in), and requires them to design and create real life structures, something that they are not used to. After university, these female students will join a workforce where their practical skills will count more than their academic ability. It is crucial therefore that this current situation be rectified before it gets worse.

4.2 Gender issues within the faculty and gender-based harassment

To begin this section, this discussion will draw on the work done by WISET (Women in Science, Engineering and Technology), an advisory group established in 1993 by Chris Schact, the Minister Assisting the Prime Minister for Science and the Minister for Science and Small Business. [12]. This group defined gender harassment as:

"… a range of exclusion, marginalizing, and resistance behaviours (usually exhibited by men) which result in women being discouraged or inhibited from access to and progression in SET (Science engineering and technology) education, training and employment. These behaviours are often subtle and sometimes unintentional. Nevertheless, they continue to have a significant impact on the way women perceive SET and careers and education in these fields."

11% of the female students that participated in this research confirmed that they had experienced some form of gender harassment at one time or other within the faculty of engineering. Gender harassment within the faculty was seen through two main dynamics; through group socialization of the male students and through the special treatment that the female students *sometimes* received from the lecturers and tutors.

4.2.1 Group socialization as a form of gender harassment

Most of the female students seemed to complain about the fact that the male students tended to hang out in seemingly impenetrable large groups. The female students said that these seemed to make them feel very uncomfortable about joining in, the conversation as it made them very self-conscious. As one female student put it:

> *"Sometimes the male students will hang out in large groups. I don't know if they do this consciously but it makes me uneasy because I tend to feel excluded"*

The female students also complained about some of the jokes that their male peers would crack at times. As one of them put it:

> *"I hate it when the male students crack jokes about women and then laugh out loud as if we are not standing there"*

In a recent study done at the university of Adelaide on the masculine nature of the culture of engineering, McLean, Copeland, O'Neill, Lewis and Linter explain the importance of joking as a way of defining masculine group dynamics [13]. They have this to say about joking:

> *"… Joking is a very important aspect of the masculine rituals of belonging, and a major way of defining who does and does not belong. Sexualised and sexist jokes emphasise that women are inferior and do not really belong. Homophobic jokes make clear the limits on*

male intimacy, and are directed at men who do not conform to masculine standards in a whole range of way."

The female students not only complained about the male students cracking exclusive jokes but also the lecturers. However, the ones that did said that this happened on very rare occasions. To quote one student:

"Most of the lecturers are very impartial but sometimes some lectures will tend to crack a joke in class that could be interpreted to have a sexist meaning. It may seem funny to other students especially the male students but on a few occasions I have felt very uncomfortable"

Nevertheless there were female students within the faculty that did not seem to be affected by this marginalizing behaviour. As one of them put it:

" I really can't say I ever feel left out or excluded, because even when the boys are hanging out in groups, I will just bulge in"

These female students came out as highly confident students that did not seem to care much about what the male students thought of them. Unfortunately not all the female engineering students fitted into this category.

4.2.2 Special treatment as a form of gender harassment

There seemed to be a general consensus that the lecturers within the faculty tended to be impartial when dealing with the students. The same was not said of the tutors. Almost half of the number of female students interviewed said that they received special treatment from the tutors. As one student put it;

"Sometimes the tutors will tend to spend an extra amount of time explaining things to me over and over. Or sometimes during the laboratories the tutors will come round and spend so much time just helping me to set up my equipment which he will not do with the male students. Its like they assume I don't know anything which makes me feel very uncomfortable."

Special treatment of minorities can be explained using Kanter's theory [14]. Kanter explains the difficulties that women face in non-traditional jobs in terms of tokenism. When a woman enters an all male work group, her colleagues judge her more critically and see her as a woman rather than a co-worker – all of which tend to work against her. The treatment she receives however is due not to the fact that she is a woman, but that she is a token (an O in a world of Xs). She is treated as a representative of her gender. The nature of group dynamics is such that any token would receive similar treatment [14]. However this argument is contradicted by another research that shows that male tokens in predominantly female jobs do not experience the same problems, as female tokens [15].

It should not go unmentioned that although some students felt uncomfortable about this, some female students do not seem to mind the attention and they find that it works to their advantage. One of them said:

"Most of the times the tutors will tend to assume I know nothing, and they will explain things to me in detail, which is okay since usually I really don't know much"

Whatever the case, this form of treatment only serves to make both the female students and the male students more aware of their sexual differences and places certain boundaries within the learning environment.

4.3 Future career aspirations

To conclude the research we asked the students what they intended to do after graduation. The results obtained are shown below

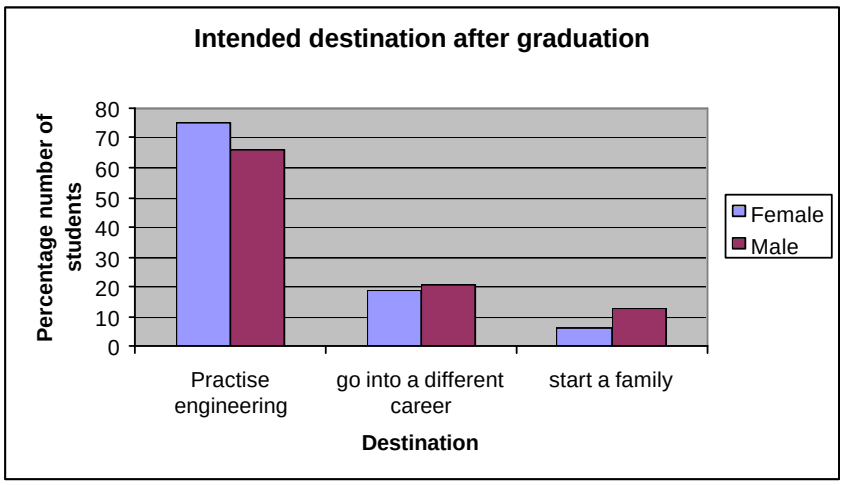

Figure 5.10: What the students intend to do after graduation; shown by gender.

There are several conclusions to draw from the figure above. First, most of the students that participated in the research wanted to get into the engineering profession after graduation (75% female, 66% male). However a higher percentage of the female students wanted to practise engineering after graduation as compared to the male students. This contradicts previous research findings that have found the attrition rates of female engineering students to be higher than those of their male peers. [16] This shows a significant improvement in the engineering field for women in engineering, since the attrition rate may be getting lower. The more women we have in engineering the easier it will be to redefine the culture of engineering. When asked why they did not intend to take up engineering after graduation, most of the male students cited a lack of interest in the profession and also that they found the course too demanding. The female students said that they found the course hard and demanding and also that they found it hard to work in a male dominated field.

5. RECOMMENDATIONS

To conclude the research the students that participated in the interviews were asked to offer suggestions on ways that the faulty could help improve their learning experience. They offered a number of suggestions. Some of the most important ones were the suggestions that the faculty

should consider spreading out the engineering course over 5 years instead of the current 4 years to reduce the amount of workload per semester. They also suggested an increase in the number of engineering scholarship made to the female students; participation of undergraduate female engineering students in the "open day" sessions (this is when the high school students visit the university in order to decide their future careers); the establishment of a mentoring program within the faculty where senior female engineering students could mentor junior female engineering students to nurture the progression of the younger engineering students and lower their drop out rates. There was also a general consensus among the female engineering students that the faculty should introduce more introductory courses that covered the areas that were taken as assumed knowledge in their practical session.

These are all measures that institutes of higher learning can adopt, more importantly now is to mention *what the global colloquium can do improve the current situation.* In Canada, as well as in the United States, a number of strategies have been used to encourage young women to consider engineering take up engineering, among them, mentoring programs, information sessions, workshops and summer camps. For example Worcester Polytechnic Institute holds an "introduce a girl to engineering day" where high school girls are invited to visit the institution and learn more about engineering. They also get a chance to participate in engineering design activities, tour various labs on campus, and ask engineering students what it's like to study engineering. This is one strategy that can be used to attract more girls to engineering.[18]

Another example is the University of Minnesota, which provides a 'Science is for Girls' summer camp for young girls interested in science, math and engineering. These camps have become very popular and other institutes like the University of Toronto and University of Texas have also adopted this strategy. Although this program is not restricted exclusively to girls, one of the stated primary objectives is to encourage more girls to get interested in science and engineering. Evidence shows that intense, hands-on, on-campus initiatives such as summer camps are most effective in educating and motivating young women to consider pursuing an engineering education. [19] The colloquium should consider introducing this camps to Australia to encourage more girls to take up engineering.

CONCLUSION

Women bring a much needed and different flavor to engineering and we cannot afford to lose them. Although currently the female students make up 17% of the Faculty of Engineering, there is still need for more females in engineering. Furthermore the research showed that about 20% of these female students do not intend to get into the engineering profession. This is the same for many universities where similar studies have been done. What is important now is not to concentrate on the inadequacies of the system but to adopt certain measures that can help improve the learning conditions of the female engineering students. A few suggestions have been offered based on work in one institution, there is room for more suggestions. If we are to learn from America and Canada then the first move should be to establish summer camps that will help educate young girls on engineering, with an aim of attracting more girls to engineering; for as long as men continue to dominate engineering, then they will continue to define the culture of engineering.

REFERENCES

1. Holland J, Blair M, Sheldon S, 1995, "*Debates and Issues in Feminist Research and Pedagogy"*, Clevedon, Avon, England ; Philadelphia : Multilingual Matters in association with the Open University.
2. Bryne E, 1985, "*Women and engineering: a comparative overview of new initiatives*", Australian Government Publishing Service, Canberra.
3. Hacker S L, 1981, "The Culture of Engineering: Woman, Workplace and Machine." *Women's Studies International Quarterly* 4: Pg 341-353
4. Connell R W, 1995, *Masculinities*, Allen and Unwin, Sydney, Australia
5. McIIwee J, Robinson J, 1992, *Women in engineering: gender, power, and workplace culture*, Albany, NY, USA: State University of NY
6. Beraud, A., 2003. A European Research on Women and Engineering Education (2001-2002), *European Journal of Engineering Education*, **28**, 435-451.
7. The University Of Sydney Statistics website, 2005, Planning Support Office, http://www.plansup.usyd.edu.au/enrol/enr04/enrfac8.htm.
8. Bourke C, Bourke E, Edwards B, 1994**.** *Aboriginal Australia : an introductory reader in Aboriginal studies*, St Lucia, Queenslandd. : University of Queensland Press.
9. Australian Bureau of Statistics (2001), Canberra, Australia. http://www.abs.gov.au/
10. Australian Institute of Family Studies, 1997, "Australian Family Briefing", *Family Matters, No.48, Spring/Summer.*
11. Smith, I. D., 1996, August, "The Impact Of Coeducational Schooling on Student Self-Concept and Achievement", *Paper presented at the biennial meeting of the International Society for the Study of Behavioural Development*, Quebec. ED 400 090.
12. WISET, 1995, The Women in Science, Engineering and Technology Advisory Group, *Women in Science, Engineering and Technology*, Australian Government Publishing Service, Canberra, May.
13. Copeland J, O'Neill B, McLean C, Lewis S, Linter S, 1997, "Masculinity and The Culture of Engineering", *Australasian Journal of Engineering Education, v.7 No.2*, Sydney.
14. Kanter R M, 1977. "Some Effects of Proportions on Group Life: Skewed Sex Ratios and Responses to Token Women," *American Journal of Sociology, v. 82, no. 5* (March): 965-990
15. Zimmer, L. 1988. Tokenism and women in the workplace: *The limits of gender-neutral theory. Social Problems*, 35, 64-77.
16. Actua learning for change, 2003, *Actua camp instuctor survey, Undergraduate students view on what influenced their choice of undergraduate field, views on the challenges facing women in engineering and approches to the acquisition of scholarships,* http://www.cemf.ca/Outreach/StatisticsResearch/CampInstructors.pdf
17. Dlamini, M. P., Ngwenya S. S., & Dlamini, B. M. (2004). Reasons girls choose agriculture or other science and technology programs in Swa ziland. *Journal of International Agricultural and Extension Education, 11*(3), 69-77. http://www.aiaee.org/jiaee/current/V11.3.69-77.pdf
18. M. Frize, 1992, "More Than Just Numbers", Report of the Canadian Committee on Women in Engineering
19. M.H. Vickers, H.L. Ching and C.B. Dean, "Do Science Programs Make a Difference?", More Than Just Numbers Conference, New Brunswick, May 1995.