

Perceptions of engineering from female secondary college students in regional Victoria

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Abstract: *Survey and focus group interviews with female students in regional Victoria resulted in identification of four perceived barriers that influence them to exclude engineering as a career choice. These barriers were identified as a lack of interest in the perceived image, a lack of knowledge, a traditionally male-dominated industry, and limited recognisable role models. This paper reports on what Year 10 females are saying about the barriers and, consequently, how engineering can be promoted to overcome these barriers.*

Keywords: *women in engineering, perceptions of engineers, promoting engineering, regional universities*

Introduction

Engineering has long been perceived as a gender-segregated industry (Cobbin, 1993), a perception that is supported by Australian Bureau of Statistics figures which puts women's participation at approximately 10% of the workforce. In this context it is pertinent to consider the perceptions of females (ages 14-15 years) and assess the impact of these perceptions and the resultant limitations in career choice.

In the context of addressing the imbalance we need to look beyond the legislative framework and recognise that diversity in the workforce has tangible benefits. A good company image that incorporates the notion of a good corporate citizen requires the adoption of society's paradigms of equity and the inclusion of society's full intellectual potential and intellectual resources. A workforce dominantly composed of white Anglo-Saxon males tends to produce similar outcomes and may limit the problem solving ability of a group. Diversity in racial, ethnic and gender groups is likely to produce diversity of thought and better problem solving capacity (cf. Institute of Engineers, Australia, 1996).

There is international concern about current and projected skills shortages in the engineering sector. Recent studies have identified skills shortages in professional engineering disciplines in regional Victoria (McKenzie, 2002). The University of Ballarat is a dual-sector institution in western Victoria that aims to serve its regional community. It is the third oldest tertiary institution in Australia, dating back to the formation of the Ballarat School of Mines in 1870, and has taught a range of engineering disciplines since that time.

Currently, engineering degree programs have less than 2% female students and will this year graduate no female engineers. While female students (both school leavers and mature entry) are normally a minority in engineering disciplines in most Universities, it has been identified that the University of Ballarat is significantly below the percentages in engineering disciplines in other Australian Universities. A project funded by the University's Equity Grant scheme was initiated to investigate the perceptions of engineering within female secondary college students (Year 10) in western Victoria. The outcome of the study should help focus future efforts to improve recruitment of female students to engineering courses and provide some indication on the impact of promotional activities, including those being undertaken by the University.

Promotional activities, supported by funding through the Victorian Government Science in Schools program, include the development of hands-on robotics classroom sessions with year 5 to Year 10 students at six schools in the Ballarat area. This program to date has involved nine teachers, ten classes and around 260 students. In addition, a growing activity in support of VCE Physics Unit 4 involves a civil engineering academic running workshops with demonstrations of concrete beam failure to over 20 schools in western Victoria. Finally, for the first time in 2003, targeted scholarships to female applicants have been offered.

This paper reports on some preliminary trends that emerged during discussions with the females focusing on their perceptions of the barriers that prevent females from choosing engineering as a career and how these barriers could be broken down.

The Methodology

This research uses qualitative research methods to gather primary data from selected participants. Such methods were preferred over quantitative approaches as they provide latitude for exploration and construction of social phenomena through an inductive process (Minichiello et al., 1995). Surveys are used as part of the participant selection process; however, the primary means of data gathering is semi-structured focus group interviewing in an attempt to access and explore females' constructions of engineers and the factors that may contribute to development of these constructions. Focus groups are used rather than individual students so as to provide a less threatening environment for students. Discussions in focus groups provide opportunities for the members to prompt each other's thought processes so that differing perspectives can come into contact (Maykut & Morehouse, 1994).

School and participants selection

Selection of schools was mostly based on student entry into the courses at the University of Ballarat for the past ten years. Eight schools agreed to participate in the study from western Victoria. The schools are classified according to the following school types to assist with theoretical sampling methods: Government Multi-campus (School B, School D); Government single-campus (School C, School E); Rural (School G); Independent (School J); Catholic

Females (School I); Catholic Co-educational (School F). Two additional schools were asked to participate but have not continued through the project.

The study targets females in Year 10 (aged 14-15 year olds) as anecdotal evidence suggests that students at this level are beginning to form ideas about career options in terms of what is realistic and academically achievable.

There were two stages involved in participant selection. The first involved gaining student consent and determining the initial sample size for each school. Nearly all Year 10 females from the schools were asked to participate in the study. The school distributed the letters, plain language statements and informed consent forms for the student and their parent/guardians. Return of both student and parent/guardian consent forms were required for the student to participate in the study. It was expected that between 160 and 180 students would provide informed consent from a total population size of about 669 year ten females at the eight schools (ie. 24%-27% participation).

The second stage in participant selection involved choosing students to form the cohort for the focus group interviews. Consenting students were asked to complete a “Career Orientation Survey” (Appendix 1) designed to indicate those students who may be open to a career in the engineering sector or similar areas. The surveys were distributed and collected by the contact teachers. Theoretical sampling (Minichiello, et al., 1995; Merriam, 1988) provided a means of selecting students on the basis of the survey results. The levels of the sampling strategy are outlined in Table 1.

LEVEL	Description
Level 1	Year 10 females
Level 2	School type (6 types)
Level 3	Student likely to choose maths/science in VCE
Level 4	Amount of thought student has given to choosing career (yes a lot, yes some)
Level 5	Whether the student is set in their career choice (no, sort of, yes)
Level 6	Type of career options mentioned

Table 1. Sampling theory for selecting students for cohort for focus group interviews. Acceptable responses are identified in parentheses. (VCE: Victorian Certificate of Education)

Focus groups were formed within schools based on information provided in the surveys. Exclusion of students was based on their lack of intention to do maths/science subjects in VCE (Level 3) and the degree of thought given to their career choice (Level 4). Information at Levels 4, 5 and 6 determined the selection of students into focus groups. The groups were predominantly homogenous groups in terms of stage of career determination (Level 4), certainty in career choice (Level 5) and the type of intended career (Level 6). Where there were by necessity lower numbers of students participating at a school, the groups were less homogenous. For larger sample sizes, the responses of surveys could be grouped at Level 4, then sub-grouped into Level 5, then three students with similar career choices could be chosen at Level 6. For example, a focus group may contain students that had given a lot of thought to choosing a career, had definitely chosen a career, and whose career choices were similar, such as all science related. In summary, the study focuses on those students who are

expected to be reasonable to high academic achievers, and have a preference for science and engineering related careers.

Focus-group interviews and analytical framework

The final cohort of students consisted of 58 females. Three or four focus-group interviews of predominantly 2-3 females of 40min to 1 ½ hr in length were conducted at each school. The study will comprise about 31 interviews. All interviews have been conducted by the principal researcher to ensure consistency. At the beginning of the interviews students were briefed on the nature of focus-group interviews (privacy issues and shared input) and the four guiding questions designed to direct the focus of the interviews:

1. What are your perceptions of engineers and engineering as a profession?
2. Have you considered or would you consider engineering as a career for yourself?
3. What are your perceptions of the University of Ballarat as an option for your tertiary education, especially in the area of engineering?
4. What has influenced the development of these images of engineers and the engineering profession, engineering at the University of Ballarat, and your choice in career?

Students were first asked to draw a poster of an engineer doing what engineers do in an appropriate environment, name the engineer and describe their work. This gave students a chance to think about their own images without being influenced by the group. It also acted as a reference point for later discussions. All interviews progressed using an interview schedule that followed the four guiding questions, however, the “flavour” of each interview was unique, depending on the depth and type of information profited and the degree of probing used by the interviewer.

The purpose of this study is not to generalise within the variety of student “types” (such as, drawing on types of career orientation) or school types (such as females catholic and co-ed catholic), but to gain insight into the variety of ideas that year 10 females have about engineers and engineering.

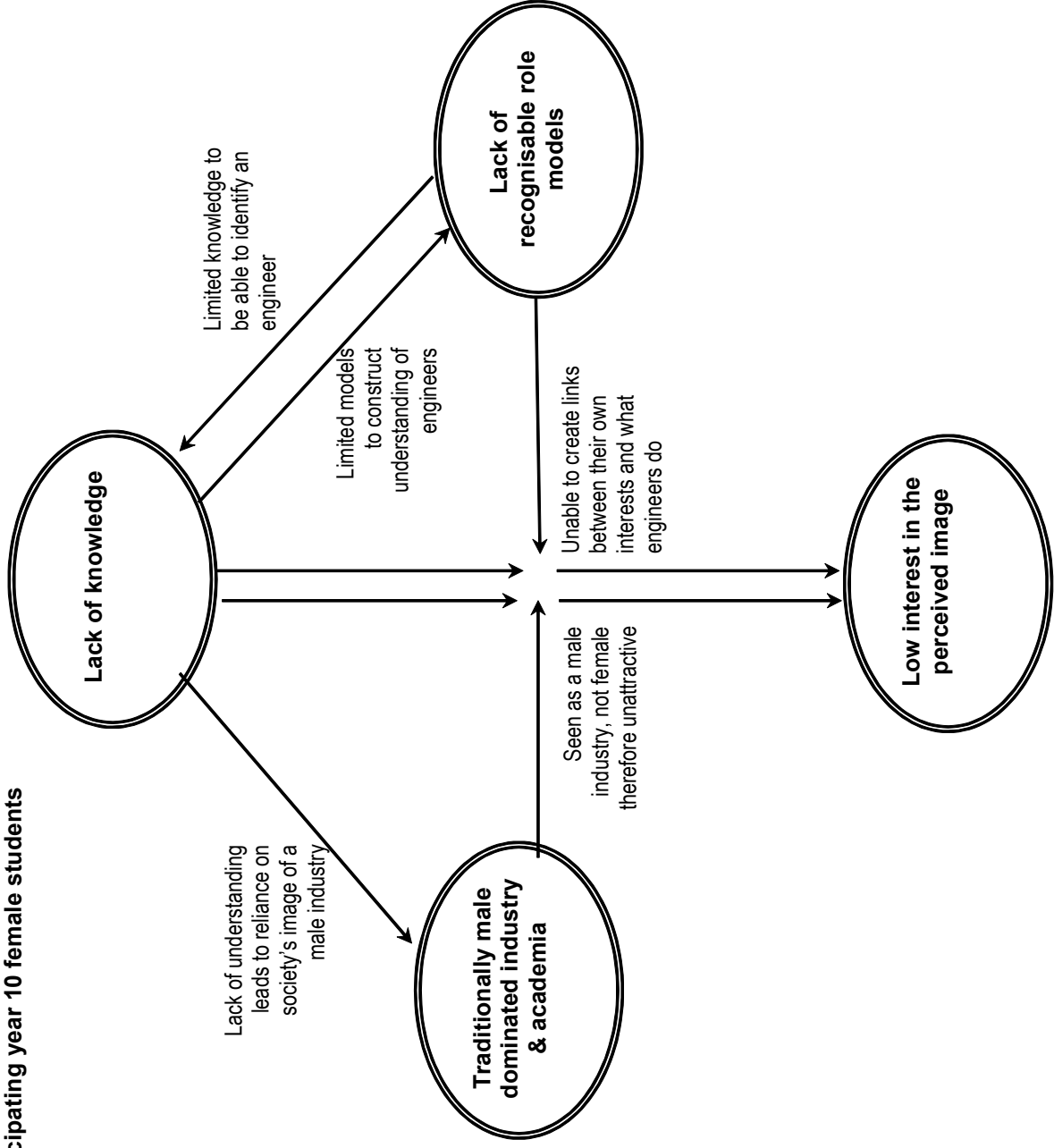
Some preliminary trends in thinking about barriers for engineering for females

Through analysis of the data it became clear that some participants were recognising barriers preventing females from choosing a career in engineering. Having discussed these barriers, some females suggested ways in which engineering could be promoted to make engineering more attractive or accessible for females.

The ideas presented here relate to the unaltered images, both accurate and inaccurate, that students captured in the poster images of engineers, because it is those images that students are probably using to make career choices at this stage.

In presenting the barriers that female students raise, the following section begins by describing what appears to be an overarching barrier, within which other barriers reside. Each of the subsumed barriers will then be looked at more closely. Diagram 1 captures some of the relationships between four barriers identified.

Diagram 1. Relationships between barriers to girls choosing engineering as a career as identified by participating year 10 female students



Identifying barriers for females choosing engineering - an overarching theme of interest

Common to all students was the conviction that career choices should be based on what the individual “enjoys”, for example, something that they are passionate about and gives them a sense of achievement. Such enjoyment emanates from their interests, and it is through the interests that students classify certain activities or qualities associated with a career as “attractive”, “appealing”, “relatable,” or conversely, “unattractive”, “boring”. The following student identifies how recognition of interests appears to be fundamental for career orientation:

“[I]f you’re interested in something you’re going to try to find what it is you can do. If you’re not interested, then you’re not going to say ‘Oh, I’ll go and look it up anyway!’” [I2]

This guidepost of interest is a fundamental barrier to females choosing engineering that appeared through the interviews. The other three barriers appear to be subsets of the student interest, perhaps contributors to the *interest barrier*, ie. a lack of interest in the perceived image of engineers and the industry.

In terms of students developing interests in engineering, the problem arises when the majority of females have a limited knowledge and understanding of the industry and its practitioners, presented here as the *knowledge barrier*, such that there appears to be a tendency to rely on the traditional male-dominated image associated with the sector. This is emulated in the following response from one female:

“[W]hat I know about it or think I know about it, I don’t really like working with metal and technology and electronics and those sort of subjects. They’re sort of boring and not really me. I like sort of more food...Cos when you think about it they’re sort of boyish, even though females do do it, I don’t picture females doing it...” [F1]

Apart from the overwhelming lack of identification with her perceived image of the engineer, the maleness and exclusivity of the types of work and the materials they work with is evident in this student’s response. This traditional male-dominated image of the engineer and the engineering industry has been recognised as a *male-dominance barrier* to females entering engineering. The perceived image of the engineer and “his” work is unattractive for her, and a career in this type of activity is passed off as male.

Drawing further on an apparent lack of knowledge in the minds of some females, an inability to “relate” their interests to an engineer due to this lack of knowledge is also a result of the failure to recognise the presence of the engineer within society:

“[I] I knew more about an engineer and what they did I’d relate more to what I like to do. But because I haven’t heard anything on TV or seen anything in newspapers, it just doesn’t appeal to me because I just don’t know anything about it.” [F1]

This leads to the *recognisable role model barrier* of there being a perceived lack of recognisable role models being projected to these females, a perception echoed by Jacobs and Scanlon (2002).

Although the above mentioned barriers appear to be intrinsically linked in the minds of these females, a closer examination of how the girls have portrayed them as a barrier can assist in giving direction in breaking down the barriers and promoting engineering for women.

How lack of knowledge excludes engineering from career choice

Many of the females had a limited awareness of some aspects of engineering. This became evident through some of the narrow portrayals of engineers on the posters and during the proceeding discussion. Commonly, the females were aware of one or two kinds of engineering that they had been exposed to, such as an aeronautical engineer, the construction engineer, the engineer who sits at a desk and designs things, the engineer who works in an environment surrounded by oily machines. Areas that some females have limited knowledge in include: the variety of types of engineering, what engineers do, the types of environment they may work in, what they may be working with, and the types of social interaction that they expect the engineer to be involved in.

Some students perceive such limited understanding as resulting from the information not being made available to them. It appears that some consider dissemination of information to students as predominantly a responsibility of their school and universities, as typified by these responses:

“We don’t really get told about engineering at all at school. You don’t hear much about it all. I think there needs to be more said about it, explained what it is more.” [F2]

“Universities should give year 10 or 11 females a go...explain it more, show them what’s involved because I don’t really know what it involves.” [J2]

Whereas, for others, knowing an engineer helps them to build an understanding:

“[Y]ou don’t learn much about what an engineer does...I don’t know anybody who’s an engineer so [I] can’t find out about what they do, or if they like their job” [J3]

Some females acknowledge that having limited knowledge presents itself as a barrier for them when choosing engineering as a career as they are not informed of what engineering offers when making decisions about careers:

“[I would probably consider engineering for myself] if I learnt a bit more about it and did a lot of research about it.” [I4]

A female who has decided that she wants to be an engineer exemplifies this. Having siblings who are engineers and doing work experience at an engineering company helped to construct her knowledge and understanding of the engineering industry: “[I want to be an engineer] because I’ve seen what they’ve done and I think ‘That could be fun, maybe I will do that.’” These perceptions are also reported in the study by Beder (1999).

Breaking down the knowledge barrier:

Analysis of the variety of responses identifies that participants appear to be addressing their lack of knowledge in two ways: thinking about what they want to know and how they want to be able to experience it.

In the first instance, students want to obtain a holistic picture of the engineer and what he or she does:

- “what they make, what they’re actually doing” [J3];
- “what their specific job is” [I4];

- “the day to day what happens, do you sit at your desk or do you get out and help do stuff, or do you work on your own or do you work in an office with engineers.” [J3];
- “explain if it’s a satisfactory job. I think give a lot of detail about it. Give lots of information about the course. What job opportunities are available” [F2];
- “the different branches they can go off into...” [F3]

The ways that this knowledge could be experienced relates to making it available in their own environment (within school) or moving into what could be considered the world of the engineer:

- “Schools would be the best place” [I4]
- “Just need to have some experience of it, maybe put I into our curriculum...” [J3]
- “Something in school, designing like a model” [J3]

and

- “Tell you and show you what they actually do with the different types” [I4]
- “You could do an excursion...put it in [females’] heads what [engineers] do” [J3]

A closer look at the lack of recognisable role models

“I don’t really know what any of the engineers do. I don’t know if these images [that we’ve drawn] are crap. There’s nothing that advertises it, nobody talks about it... But with engineering there’s like nothing that would advertise it. And then when you get the images, the only ones around you saying they want to be an engineer are guys, so you just get an image in your head that it’s a guy thing.” [F1]

The above response suggests the perceptions that engineers tend to be “behind the scenes,” and are not widely advertised or represented in the media. As a barrier to females choosing engineering, without the awareness of it, decision making about career orientation fails to include engineering as a potential interest, as exemplified by the following response:

“If I knew what one is, I might know [if I knew someone who was an engineer]. See I probably do know someone but I don’t know what it is.” [F1]

It became evident during the discussions that the females construct their image of the engineer from their life experiences, especially through personal contact with engineers or people that share with them in some way what engineers are and do. Such people included parents, relatives who have been engineers, teachers, such as a science teacher who equated the current topic of physics to engineering, and resources available from school, including careers booklets or Internet searches for careers information.

The media appears to have played an important role in educating students and providing a recognisable image of the engineer. One student mentioned a movie with an engineer that builds models. As this is the only exposure she has had to engineers, her poster reflects the processes and activities that she saw the engineer involved in, namely designing and constructing models for buildings.

Breaking down the recognition barrier:

Not having a recognisable image or role model appears to often leave the females with a limited knowledge. Conversely, without the knowledge to be able to recognise what an

engineer is, evidence of engineers and engineering activities remain unnoticed, as expressed by this student.

“If they hear people talk and say that it’s a good thing and make people think about it cos otherwise they don’t think about it, because otherwise they don’t recognise it that much.” [F1] Commonly, students suggested raising an awareness of the role and image of the engineer so as to promote a consciousness of their presence in society. Consequently, education aimed at increasing the awareness of engineering should provide both information about them and offer role models that are prominent in the community.

A closer look at the image of a male industry

Of all posters, 23 posters represented male images, with nine female images. Four of those participants who represented female images were related to a female engineer. Another two participants said that initially they would have drawn a male but were influenced by the rationale for this research. The opinion of many can be captured as: “Engineers just sound manly” [I4] and “I think it’s a guy thing” [I4].

Students appear to be recognising two influences dominating their perspective on how gender typing relates to career orientation. The first influence is the societal influence: “It’s just a social thing. Its got nothing to do with ability” [I2]. Within this view males and females are considered equal, and it is more the societal pressure that influences females’ tendency to remove engineering from their choices. For a number of females, interest transcends societal pressure: “If you think it’s male-dominated then it becomes that in your mind... If I really wanted to do it, I’d do it. I wouldn’t let that stop me.” [I3] With this mindset, engineering becomes accessible for females as the construction of gender bias is removed from the equation.

The other influence is the recognition of the differences between males and females: many females equated males with the image of engineers more readily than females because “[i]t’s sort of an innate ability for guys, with the whole engineering side, they know what it is, they’ve been playing around it for as long as they could walk with dad and pa.” [F3] The phenomena of the “guy thing” and “girl thing” evolves from this difference, and presents itself as a barrier due to a lack of females being able to identify with the male engineer. For one female whose perception of engineering is centred on building design and construction, designing may be common for both genders, but it is the materials that are being worked that differentiates: “Most females that are designers they design clothes rather than buildings cos buildings are sort of a guy thing...guys like big things and tractors and big construction things. They’re like, ‘I want to design that.’ It’s not such a female thing.” [J3]

Breaking down the barrier:

Changing the male-dominated image as perceived by these females, either as a product of social construction or as the innate characteristic, requires presenting the industry as not just for men and “not a sexist thing” [J4]. This deals predominantly with putting women into the engineering role: “you’d need to see actual women on the job” [F1]. A number of suggestions were made as to how the images presented to females could include the female image. For example, posters depicting women doing the variety of roles, and males and females working together targeting the idea that females can do the work and that there is a level of collaboration and harmony within the work environment. The value of projecting a “unisex” [J4] environment, a student recognizes, is that “females might feel more comfortable in that environment” [J4]. One female warns that efforts to make engineering

more attractive for females should not present an unrealistic image for females: “if I was looking at it I wouldn’t want it as female engineering, you’d want it to be engineering the same as male...you’d want to say it’s not just males who can do engineering, females are just as good” [J4]. Personal contact with female role models from the engineering industry were also considered important, such as females talking to students at schools, females taking on presenting roles during school visits, and at University Open days, career days and during university visits. A woman engineer talking to females only was suggested in one interview so as to allow the female voice to be heard and not muffled by the male voice. The value of getting this female face of the industry is that they can “get a woman’s point of view” [F3], get a taste of “whether they enjoy it” [F1] and there is an opportunity to hear how it actually is for females.

Conclusion

This on-going research project has identified similar issues to other recent researchers and provides support for the needs of a number of regional, national and international initiatives to promote engineering. For these year 10 females the real barriers to women choosing to study engineering at University are substantial and go well beyond the image of the profession. They encompass a lack of interest in the perceived image of engineers and the profession, misunderstandings about the nature of the work, lack of exposure to professionals and the negative perceptions of a male dominated industry.

References

- Beder, S. (1999). Beyond technicalities: Expanding engineering thinking. *Journal of Professional Issues in Engineering*, 125(1), 12-18.
- Cobbin, D. (1994). *Women’s participation in non-traditional fields of study at the undergraduate level of higher education 1983-1993*. Sydney: University of Technology.
- Institute of Engineers, Australia. (1996). *Changing the culture: Engineering education into the future*. Barton: Institute of Engineers, Australia.
- Maykut, P., & Morehouse, R. (1994). *Beginning qualitative research: A philosophical and practical guide*. London: Falmer Press.
- McKenzie, F. (2002). New ways of seeing regional issues: Using information to move beyond stereotypes. *Sustaining Regions*, 2(2), 12-26.
- Merriam, S. B. (1988). *Case Study Research in Education*. San Fransisco: Jossey Bass Inc.
- Minichiello, V., Aroni, R., Timewell, E., & Alexander, L. (1995). *In-depth interviewing: Principles, techniques, analysis* (2 ed.). Melbourne: Longman.