Pilot Exploration of Gender Inclusivity of Engineering Students’ Exposure to Engineering Practice in an Australian University

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To society’s detriment, women remain under-represented among engineering students and practicing engineers in Australia. Many studies have shown that engineering workplaces have features that are not gender inclusive. Efforts to improve engineering education by increasing industry engagement might therefore also result in non-inclusive student experiences, with potentially detrimental outcomes. This paper reports on a pilot investigation of the gender inclusivity of industry engagement by student engineers. We explored experiences of exposure to engineering practice by students who were studying at an urban Australian university. The study used the framework of possible selves, which examines the factors that motivate people to achieve or avoid possible future selves (Markus and Nurius, 1986). Through interviews with four female and two male engineering students we discovered gendered encounters experienced by students and the impacts these had on their perception of their future and their current directions. The female students reported marginalising gendered encounters similar to those reported by female engineers in other studies. The pilot highlights the need for further investigation.

Keywords: Gender, engineering education, work integrated learning, curriculum development, possible selves theory
1. Introduction

Women remain unrepresented among engineers, and student engineers, in Australia. Only 11.8% of the supply of engineers was female at the last census in 2011 (Kaspura, 2012, p1). This under-representation of women in a profession that is critical both to current prosperity and to a sustainable future, represents a loss for society and a missed opportunity for many women. Similar issues arise in New Zealand, Canada, the UK, the USA, and Western Europe (Charles and Bradley, 2009). Since the 1980s, programs have been undertaken across Australia to improve recruitment of female engineering students. While there have been transient successes, female percentages of domestic bachelor degree completions in engineering and related technologies were only 15.0% in 2012 (Kaspura, 2014, p. 34). In Australia, female engineering students have had higher success rates than male engineering students (King, 2008). Godfrey and King (2011) reported that female engineering students had higher retention rates than men but were more likely than male students to switch to a different field during or from their first year. Table 1 presents most recently available retention rates.

Table 1: Annual retention rates of full time domestic bachelor students in engineering and institution in 2011

<table>
<thead>
<tr>
<th>Year level</th>
<th>Male Students</th>
<th>Female Students</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commencing students</td>
<td>83.5</td>
<td>82.5</td>
</tr>
<tr>
<td>All students</td>
<td>86.4</td>
<td>87.0</td>
</tr>
</tbody>
</table>

Note: Retention rates are reported by Kaspura (2014, p. 40). Retention rates represent percentages of students enrolling in engineering and in the same institution in the following year, or graduating. Students who remain in engineering but change institutions are not included in the rate. Commencing students include all students new to the program and the institution and are not limited to students in first year (Godfrey and King, 2011).
After graduation, however, women leave the profession at higher rates than men. In 2006, 62.6% of the qualified male engineers, and only 47.1% of qualified female engineers, were employed in engineering occupations (Kaspura, 2014, p. 9).

In countries where women are under-represented in engineering, workplace cultures are thought to be influential in the departure of women from the profession (Mills et al., 2008, Gill et al., 2008, Singh et al., 2014). In an Australian survey in 2012, 23.6% of 932 female engineers reported personal experience of sexual harassment and 35.4% of the female respondents reported experiencing discrimination (Kaspura, 2012, p50-51). In 2010 the median salary of female engineers with five to ten years of experience was 8.5% less than that of male engineers with the same duration of experience (The Association of Professional Engineers Scientists and Managers Australia, 2010). The estimated unemployment rate for female qualified engineers in 2011, at 6.1%, was almost twice as high as for male qualified engineers at 3.2% (Kaspura, 2014, p9). There is also an indication of barriers to women with children in the profession. In 2007, the 767 female engineers participating in the Career Review of Engineering Women survey reported fewer children (0.37 on average) than women in other professions (1.7 on average) or male engineering participants (1.99 on average) (Mills et al., 2008, p17). 71.6% of female engineers surveyed in 2009 believed that taking maternity leave (including unpaid leave) was likely to be detrimental to their career (Association of Professional Engineers Scientists & Managers Australia, 2010, p7). These examples provide substantial evidence that engineering workplaces in Australia have features that are not gender inclusive.

Concurrently, it has been recognised internationally that there is a gap between the competencies developed by engineering graduates and those required for engineering practice (Male, 2010). To bridge the gap, engineering educators include opportunities for students to
be exposed to engineering practice through industry engagement in engineering programs (Bradley, 2008). For example, most engineering curricula in Australia include a minimum of 12 weeks of practicum or longer internships. Smith and coworkers (2014) reported that well-managed work integrated learning helps students to develop generic attributes for work readiness in many disciplines. Although there are examples of well-structured work integrated learning in engineering, workplace learning by engineering students in Australia usually has little or no involvement by the university. Interest in improving work integrated learning in engineering is strong. There have been calls for exposure to engineering practice to be increased (Sheppard et al., 2009) and the Australian Council of Engineering Deans recently completed a project to improve the quantity and employability of engineering graduates by enhancing industry engagement in engineering degrees (Male and King, 2014).

In the context of high female attrition from engineering programs and the engineering workforce, it is important to discover and understand any differences between how male and female engineering students experience exposure to engineering practice, and ensure that exposure to practice is gender inclusive.

This manuscript reports a pilot study to explore gender inclusivity of engineering students’ experiences of exposure to practice at an Australian university, and discover whether further investigation is necessary.

1.1. Previous research

Much research has been undertaken on designing gender inclusive engineering curricula (Godfrey and King, 2011, Godfrey, 2003, Mills et al., 2010b). None of these specifically focused on the gender inclusivity of exposure to practice in Australia, and yet in combination they point to the need for this.
Mills and coworkers (2010a, pp.62-27) raised the significance of identity development as part of designing gender inclusive engineering education. Godfrey (2003) investigated the culture of an engineering faculty in New Zealand, finding features consistent with a gendered culture. Studies of engineering workplace cultures in Australia concluded with recommendations that engineering curricula should include education about workplace cultures (Gill et al., 2008). Godfrey and King (2011) investigated students’ attrition and success in Australian engineering programs. They reported the need for improved gender inclusivity in engineering curricula but did not comment specifically on the gender inclusivity of workplace learning. In an apprenticeship engineering program in France, Blandin (2012) found that respect from colleagues was influential for students in their development of professional engineering identities.

Studies directly investigating workplace experiences in this context have taken place in the USA and UK. Tonso (2007), in her study of project-based learning in an engineering school in the USA, included investigation of gender and identity in workplace experiences of students. She found differences in power and recognition experienced by female and male students. Most importantly, Powell and coworkers (2009) interviewed 26 female engineering students before, during, and after industry placements in the UK. They identified the students’ responses to the masculine culture as ‘acting like one of the boys’, ‘accepting gender discrimination’ and ‘achieving a reputation’, seeing ‘advantages over disadvantages’ or adopting an ‘anti-woman approach’ (pp. 418–21). They explained gender conflict that can arise, but a detailed account of the range of gendered experiences of the students in the workplace was beyond the scope of the paper. Hatmaker (2013, p386), in her study of 52 female engineers in the USA, found that personal interactions with others in the workplace marginalised the professional identity of the female engineers by: ‘(a) amplifying gender, (b) imposing gendered expectations, (c) tuning out and (d) doubting technical abilities’. In a
similar manner to Powell and coworkers, Hatmaker identifies engineers’ responses and consequent outcomes.

There is additionally a vast literature on the gendered nature of engineering organizations and initiatives to improve the status of women in engineering (Barnard et al., 2010, Lewis et al., 2007).

1.2. Theoretical framework

This study was positioned within the theoretical framework of possible selves (Markus and Nurius, 1986). Within this theory students are understood to be motivated in their studies by awareness of appealing possible future selves that they perceive to be achievable, and demotivated by awareness of disconcerting possible future selves. The theory links students’ awareness to their motivation for their studies and was therefore expected to help explain how students’ awareness of engineering practice, developed through exposure to practice, influences their motivation towards their engineering studies.

The research questions, interview questions and analysis are derived from the theory of possible selves and the importance of encounters or personal interactions in gendered workplace cultures as identified by Hatmaker (2013) and Powell, Bagilhole and Dainty (2009).

1.3. Research questions

Following the possible selves model, we sought evidence to address the following questions:

Q1. Are engineering students gaining awareness of appealing possible future engineering roles through industry engagement in their programs, and if so what are examples of features of these roles?
Q2. Are engineering students gaining awareness of disconcerting possible future engineering roles through industry engagement in their programs, and if so what are examples of features of these roles?

Q3. Are engineering students experiencing encounters that are encouraging through industry engagement in their programs, and if so what are examples?

Q4. Are engineering students experiencing encounters that are disconcerting through industry engagement in their programs, and if so what are examples?

Q5. Do engineering students report changes in career identity or enrolment intentions as a consequence of experiences of industry engagement, and if so what are examples?

Q6. Are any of the examples in response to questions 1 to 5 consistent with gendered workplace cultures?

1.4. Context

The study was undertaken at an urban university in Australia where the most significant exposure to engineering practice is the engineering practicum consisting of twelve weeks’ relevant employment, usually undertaken as vacation employment and increasingly as part-time work during semester.

The university is in a state where resource industries are significant. At the time of the interviews, in mid-2013, a mining boom was beginning to slow. Many workers in the industry ‘fly-in-fly-out’ on a cycle including periods on site and at home.

2. Method

This study was designed to discover whether there was evidence consistent with a problem, rather than measuring the size of the problem or describing the diversity of the problem. A
small sample of students was interviewed, as detailed below, with ethics approval. Interviews allowed deep exploration of topics raised by the students rather than anticipated by the researchers (Mertens, 2005).

An invitation to participate was emailed from the second author to all engineering students who had indicated they expected to complete their degrees at the end of 2013. Students replied to and were interviewed by the first author, who had no teaching or administrative responsibilities. Students were interviewed in groups of two to four students to help students to reflect on their experiences.

On arrival, students completed a one-page demographic questionnaire. Interviews lasted one hour including light lunch, and were recorded and transcribed. The interviewer removed identifying material before sharing the transcripts with the second author. The interview questions are below. Because the students were interviewed in pairs, their interaction enriched the discussion. For example, comments from students prompted similar examples, and at other times surprise and contrasting comments, from other students. This interaction led to voluntary elaboration by the students.

**Interview Questions**

1. Have you undertaken vacation employment?
2. If you had the opportunity would you like to work for the same employer or in similar work later in your life? Why or why not?
3. During your vacation employment [or other exposure to practice if not vacation experience (similarly below)] did you experience encounters with others that were positive for your identity as a future engineer (e.g. respectful, encouraging)? Explain.
4. During your vacation employment did you experience encounters with others that were disconcerting for your identity as a future engineer (e.g. respectful, encouraging)? Explain.
5. During your vacation employment, were you aware of any roles of engineers that appealed to you as a possible future role for you?
6. If yes, do you feel that this is achievable and why?
During your vacation employment, were you aware of any roles of engineers that you would like to avoid as a possible future role for you? Which and why?

Aside from personal encounters and appealing or disconcerting roles that you were aware of, were there any other aspects of your vacation employment experience that were especially encouraging or disconcerting?

Overall how did you change most significantly as a result of your vacation employment?

2.1. Participants

The first two interviews were each attended by two female students (denoted Students 1 and 2, 3 and 4 respectively). The third interview was held immediately following the second and was attended by Students 3 and 4 and two male students (5 and 6). The students were aged from 22 to 24, enrolled as domestic students in their final year of an engineering degree.

Participant demographic details are presented in Table 2.

Table 2: Participants

<table>
<thead>
<tr>
<th>Student</th>
<th>Gender</th>
<th>Engineering discipline</th>
<th>Engineer father and/or uncle</th>
<th>Engineer close friend</th>
<th>Number of engineering organisations in which student had worked during studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>female</td>
<td>electrical</td>
<td>yes</td>
<td>no</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>female</td>
<td>mechanical (oil and gas)</td>
<td>no</td>
<td>no</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>female</td>
<td>mechatronic</td>
<td>yes</td>
<td>no</td>
<td>2</td>
</tr>
<tr>
<td>4</td>
<td>female</td>
<td>mechatronic</td>
<td>no</td>
<td>yes</td>
<td>1</td>
</tr>
<tr>
<td>5</td>
<td>male</td>
<td>mechanical</td>
<td>yes</td>
<td>yes</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>male</td>
<td>mechanical</td>
<td>no</td>
<td>yes</td>
<td>2</td>
</tr>
</tbody>
</table>

Note: Students were asked whether they had a close relative or friend who was an engineer.

Students nominated as the relatives their fathers and uncles.

Only Student 3 had worked in an engineering-based organisation before engineering studies, with three months’ experience before beginning her engineering education. All students had
been paid during their employment in engineering organisations, except when Students 5 and 6 worked for the motorsports team at the university.

2.2. Analysis

Transcripts were analysed for comments that were consistent with a student identifying a feature of a possible future engineering role as appealing or disconcerting (Q1 and 2); or feeling encouraged or disconcerted by encounters (Q3 and 4). All responses were analysed to discover any evidence of identity development (Q5) and all responses previously identified were further analysed to determine whether the identified comments were consistent with gendered workplace cultures (Q6).

3. Findings and Discussion

Identified perceptions of appealing and disconcerting possible selves (Q1 and 2) and encouraging and disconcerting encounters (Q3 and 4) are listed below. Identity development (Q5) and consistency with gendered cultures (Q6) are presented throughout.

3.1. Male Students’ Experiences

Appealing Possible Selves (Q1)

The male students’ perceptions of appealing possible future roles included the following features.

- Doing something useful for people
- Having opportunity to be creative / doing something new
- Being expert at something
- Doing challenging work
• Doing work that maintains opportunities for a breadth of career path, and is relevant in diverse industries

• Managing projects

Below, both male students discussed the appeal of being expert.

At [machinery company] I see a lot of people in [another machinery company] who have just been engineers and have been there for 20 years and have honed their trade, and I think that’s pretty cool because they’re really, really awesome at what they do. (Student 6)

I think that’s an attractive thing… being awesome in… one area,… getting really, really good over and over again. (Student 5)

But I really like just learning a little bit and then, well we get a problem at [machinery company] and I can apply something,… and I’m just really happy,… There’s so many moments at motor sport as well when you find some little cool engineering thing… ‘Oh, look at that…. That little engineering wonder thing does this.’ (Student 6)

Student 5 referred to project management as an appealing possible future role:

I guess from my degree experience,… I used to want to do… computer stuff, just designing things on computers and now that doesn’t appeal to me at all. I used to think… ‘project management, I don’t want anything to do with that’. Well,… I had a complete misunderstanding of what it was, so I took on the project management role at motorsport and now I’m just totally involved in it and really interested. It was
weird, like I turned from an engineer into something of a social scientist or something.

In the above words Student 5 revealed identity development (Q5). The engineering program had focused his interests on designing with computers. His experience with motorsport gave him an interest in project management, which he perceived to be a social science rather than engineering. This is consistent with the conflict in identity that Faulkner (2007) observed in engineers when they discovered that their work was as much social as technical. The expectation of engineering as purely technical is consistent with a gendered culture in engineering faculties in which abstract competencies are given higher status than competencies that are stereotypically feminine (Hacker, 1981) (Q6).

**Disconcerting Possible Selves (Q2)**

The disconcerting features of possible future roles identified in the male students’ responses are:

- Working in a role that is not challenging
- Being restricted to one industry

In the words of Student 6,

*I do design work,... but it’s not challenging.... Being mining, money’s not an issue, weight isn’t an issue, so it’s... just... the easiest thing to make all the time... It was good, but... you... wonder how this is going to be in about... ten years... I’ve become... disillusioned with... the lack of opportunity outside resources.*

**Encounters (Q3 and Q4)**
The male students both enjoyed learning from tradespeople. They described making mistakes and being supported to learn:

*Particularly for motor sport, you get to... chat with all the dudes who are manufacturing your part and they give you direct feedback... They might laugh at you, ‘You can’t make that’,... because you make really funny errors. But... being able to directly talk with them and learn from... some real hard lessons... it’s really good.*
(Student 5)

*The only interaction I have is with the fabricators... and the machinists... I’d draw something up... They’d give me a lot of immediate feedback, and then I’d get the drawings back with scribbles: ‘This is crap. This is inefficient. Why have you done this?’ So that’s really good.* (Student 6)

**Identity Development**

Below, Student 5 reported discovering there was much he did not know and taking responsibility for his learning, and Student 6 echoes this. This is consistent with them developing identities as ‘student engineers’ rather than engineering students (Lindsay et al., 2008).

*I came into the [motorsport] team and I was, ‘How the heck are they doing that? I don’t know how to design this part... I don’t know what I’m doing. I don’t know anything.’ and then from there, ‘It’s okay that I don’t know, but I’m capable of finding out and doing something about it.’ That fundamental change in mindset from someone should tell me what to do to, ‘No, you’re an engineer.... Work out how to solve the problem.’* (Student 5)

*Motor sport... showed me that I knew nothing, which was cool.* (Student 6)
3.2. Female Students’ Experiences

Appealing Possible Selves (Q1)

Appealing features of possible future roles identified in the female students’ responses were,

- Doing challenging work that uses things learned in her studies (similar to the male students)
- Working in renewable energy
- Maintaining opportunities for a breadth of career path (similar to the male students)
- Having the satisfaction of seeing a project from the beginning
- Working in an organisation with flexible hours
- Working in an organisation with diverse people
- Discovering something new (similar to ‘doing something new’ identified by the male students)
- Having job security.

Three items are similar to items identified by the male students. Others are consistent with literature. Renewable energy is known as a field of engineering that is more attractive to women than other fields. Flexibility is recognised as important to female engineers (Ayre et al., 2013). Student 3 already valued flexibility:

*There were a lot of… flexible hours, people that worked part-time… Seeing that there were other ways of doing engineering… made me feel so much better about my degree, because I was almost considering if I should transfer to medicine… I’ve an aunt that’s a doctor and she works less hours than my dad does [as an engineer].*
Student 1 enjoyed discovering something new in her research and was considering undertaking a PhD. In contrast, Student 3 had job security as a high priority:

*With the current economic climate I felt there was more job security with [oil and gas company],... because... during the downturn... [consulting firm] did let quite a few people go... because consultancies, although they did more interesting work,... they were hit harder because all of the large companies bring everything in-house.*

Both Student 1’s interest in new challenges and Student 3’s interest in job security were among career decision factors of women in the Australian mining industry that were identified by Nowak and coworkers (2014).

**Disconcerting Possible Selves (Q2)**

Features of possible future roles that the female students wished to avoid were,

- Living far away from the conveniences of a city
- Being restricted to a narrow role such as maintenance (similar to the male students’ fear of being restricted to one industry)
- Working with tradespeople or technicians who might not understand or respect professional engineers, leading to the need to gain their respect
- Working in a role that is not interesting or not challenging (as feared by the male students)
- Sitting in an office and not getting out in the field
- Long hours
- High intensity
- Competition.
This list also contains two items similar to those feared by male students and other items are consistent with literature. Competition, for example, is recognised as unappealing for female students. Here we have a student extending this sentiment to workplace expectations.

Student 1 reported her experience of a camp offered by a mining company. Her reflection is consistent with Nowak and coworkers’ (2014) conclusion, based on similar comments from women in the Australian mining industry, that perceptions of work-life balance that influence career decisions are broader than balancing time between career and family:

> We stayed in the place that miners stay in... I don’t think I could live there. I could do fly-in-fly-out, but... I think it would be really hard to stay... where... you’re completely secluded from.... going out seeing a movie,... meeting friends.

Additionally, Student 2 was deterred by her perception of limited roles in mining:

> Within mining, mechanical engineers are generally with maintenance and I didn’t really realise that until after I worked there... I was never interested in cars or things like that... The job involved... overseeing maintenance and planning the fixing of trucks.

In contrast, Student 4 indicated that working in the office all day was unappealing:

> I hoped to get on out into the field a bit more than... I was... sitting around in the office... So I still don’t know whether or not it’s the right career for me and whether in ten, 15 years I’ll still be enjoying it.

Additionally, Student 4 reported a lack of awareness of an appealing possible future self and lack of confidence that she would enjoy working as an engineer:
No one in my family is an engineer... so I really had no idea... what kind of work would you actually do as an engineer..., and then my vac work - I was basically surrounded by other accountants and people who did commerce... - and so I still don’t quite have that question answered. I’m still doing the whole, do the grad program, see where I go from there. If it turns out that it’s not for me, then... I’ll find something else.... Very uncertain... sums it up.

As noted above in the appealing possible futures, Student 3 was pleased to discover that engineers could work flexible hours, because it alleviated the concern she describes below:

[My father]’s a civil and structural engineer. I do not want to be one of those ever.

Why is that? (interviewer)

There was a point in high school where he would leave to go to work before I woke up in the morning and I was waking up at five, and he would come home after I went to sleep... every day of the week, including Saturday and Sunday.

Below Student 3 described constant intensity and long hours as unappealing.

When I was at [oil and gas company] my grad buddy... set me up with... meetings with people from... other... departments... and one... was... an operational maintenance... thing, where you got an email in the morning telling you something’s gone wrong, fix it - an engineer’s job. And you... had to diagnose the problem... and come up with a solution as soon as possible,... as soon as you finished one, another one would come in, and it was... intensive and long hours.... I don’t really want to do that.

Student 3 also described competition as disconcerting:
The other girl… at [oil and gas company] with me… was offered a job and she actually turned it down because she found that the vacation program… had a large portion of people… who are very… driven. They wanted [graduate jobs] so bad… that it became,… overly competitive, with people being a little bit nasty.

**Encouraging Encounters (Q3)**

At least one female student reported experiencing each of the following encounters as encouraging.

- Speaking with recent graduate engineers and their supervisors
- Praise for successful work / Having contributions acknowledged
- Discovering that engineering work is not magic
- Being offered graduate positions
- Gaining the respect of tradespeople or technicians
- Being told that their qualification will be valuable for the role

Student 1 described the value of speaking with recent graduate engineers.

*I feel speaking with the younger… engineers… was a positive experience because… they’ve been in your place… It’s nice to see someone like… you in the future.*

Student 3 described gaining respect and having her contribution acknowledged.

*I was happy in my role, despite… the incidents… even dealing with the external contractor and having them direct things to my supervisor. By the end of the project one of them… was like ‘Wow you’re really soaking things up like a sponge here. You really are in this project now.’*
These comments and the students’ appreciation of being offered graduate positions are consistent with Blandin’s (2012) observations that respect from others in the workplace and being given responsible positions are important for students’ identity development and motivation.

The third item is similar and can be explained by possible selves theory, which links students’ motivation to awareness of appealing possible future selves. As discussed, it is important that the appealing possible future self is also perceived by the student as achievable. In the words of Student 2,

*I think it was really good to see what engineers did… I never really knew someone who was an engineer… I only really got into it because I liked the maths and physics… Even though I was doing it I was always… thinking that I don’t know if I can be – I don’t know what an engineer does… And… I’d… think that they’re doing something that’s way beyond my level. But going on vacation work… changed me to think,… ’No,… I understand what they’re doing and I could do that…’ So that was really encouraging because… I thought that I didn’t know very much, but actually… seeing what they did: it wasn’t magic… Changing into university… they teach you really technical … difficult things, and then the average of a class is 65 per cent. So there’s always this part of it that you just don’t know and I… felt like I was… trying to pass, and if you do, it’s like… you’ve tricked them.*

Female engineering students are more likely to lack confidence than male students (Goodman et al., 2002, Marra et al., 2005). Student 2 raised the issue of self-efficacy to practise engineering after graduating.

**Disconcerting Encounters (Q4 and Q6)**
Each of the four categories of marginalising encounters that Hatmaker (2013) identified as experienced by female engineers was experienced by at least one female student in the study, consistent with gendered workplace cultures (Q6).

Student 3’s gender was amplified when she had to use the toilet in the medical centre on an offshore rig because there were no female toilets. It was further amplified, in the encounter below experienced with the only other woman on the rig, also a student.

_We were talking to some people and they say ‘Oh we can’t tell this joke.’ And we’re like ‘Oh you shouldn’t really treat us differently.’ And then the joke came out ‘What makes nine out of ten people happy? Gang rape.’_

Student 4’s colleagues imposed gender expectations:

_There was a time in the office they were offering around chocolates ‘Oh no sorry don’t like it’ ‘What? A women who doesn’t like chocolate?’ And made a bit of a big deal about it._

Student 3, quoted above as enjoying praise, had initially experienced tuning out:

_There... were... three representatives and my supervisor and... I was speaking to the person directly across from me and the third person started speaking across to my supervisor whilst I was trying to talk... Or they would ask a question to the supervisor, I would respond, the next question would go to my supervisor... There was another time... with my supervisor and I standing with another guy and he’s like ‘So what are you actually using this for?’ and I responded but it was... - even though there were three of us there - ... just between him and my supervisor and even with me trying to explain. ... I can certainly understand that when you’re dealing with a_
vacation student perhaps you do want to speak to somebody more senior, ... but still

I’m given as your point of contact and I’m the one making the $50,000.00 decision on
whether we employ you or not, maybe you should be talking to me.

Male and female students had their technical abilities doubted by tradespeople, drafters, or technicians. The men in the workplace were happy to help the male students. However tradesmen and technicians were reluctant to help the female students until the students had gained their respect. In the words of Student 2,

Where I was working there was a lot of tradesmen in the workshop and interacting with them was a bit more difficult... At the start it was really difficult... because there’s a lot of them and they don’t respect... education. So... you... have to start at the bottom with them, whereas... engineers... know where you’ve come from...And I found that it took a while and a different kind of approach with the tradesmen. You... needed to show them... that you’re willing to get dirty... One of the times I really felt like I made some ground, I noticed one of the guys – one of the older... tradesmen who... had been the nicest to me... - and I... said, ‘I really don’t know anything. Can I spend the day with you and see how it works?’ .... By the end of the day I was... really dirty.... It was the only time... the guys in the workshop seemed to acknowledge me... I think I just needed to break this barrier.

Below, Student 1 reported having to prove herself with the technicians. Before she was accepted by the technicians she had felt she was a burden having to ask for help because she would be given a small piece of information and then have to return for the next step. Otherwise the student would be sent to help someone else and find she did not have the skills for that either. This experience was described by three of the four female students interviewed.
Sometimes I was asked to help with actually assembling things, ... and I always had to ask them... because I had no idea which tool to use or... They’re mostly electricians and they didn’t know what I was supposed to be doing... I felt like I was a burden because I always had to ask, ‘How do I do this? I have no idea. I’ve never assembled anything before.’... I was the only girl at the workshop. ... But... a positive thing happened – when an electrician came to where I was working, and one time I was given a project where I was working on actual electronics, so really small resistors and stuff. And he was, ‘Oh, so that’s actually what you do?’

Student 1 described how she built a perception of an unappealing possible future role from a series of encounters. This was sufficiently concerning for her to doubt her career intentions and modify her enrolment:

I thought the tradesmen thing was difficult and it made me realise that I’m not sure if I would like to go in to an area where I’m surrounded by tradespeople because... I would hear the things that they would say about the actual engineers and the actual bosses..., ‘They just sit in the office all day. They don’t do anything.’ ... And I... remember thinking that it would be a constant challenge every day if I was to work here... I wouldn’t like to be in that situation where the tradesmen were talking bad about me...

After Company X, I decided... if that Company X represented the industry, which I realised later that it didn’t,... it would be good for me to take another degree as a backup... because I always thought engineering was what I wanted to do ever since I was 10, and then... after working in Company X... I thought I might do another degree... just in case I change my mind later.
Student 1 experienced a disconcerting culture and, based on this, perceived a possible future environment in which she could find herself if she continued to work in the organisation. This caused her to doubt her career choice and degree program. The student’s conclusion is consistent with the numerous studies that have reported female engineers being frustrated by needing to prove themselves to every new team they joined because their credibility was doubted while men’s credibility was assumed (e.g., Gill et al., 2008, Miller, 2004).

### 3.3. Limitations

In this pilot study we interviewed only four female and two male students. Further studies with domestic and international students from multiple institutions and engineering degrees are needed. Other types of exposure to engineering practice such as industry-based projects with industry supervisors should also be investigated. Approaches could include investigation of experiences from the point of view of students, engineering educators, and employers.

### 4. Conclusions

Among just six engineering students we discovered examples of male and female students becoming aware of appealing possible future roles (Q1) and feeling encouraged by personal encounters (Q3). Examples of features of appealing possible future roles (Q1) for male and female students included challenge, continuing variety of opportunities, and doing or discovering something new. Additionally, male students noted the appeal of doing something useful for people, being experts and managing projects; and female students noted the satisfaction of seeing a project from the beginning to the end, flexible hours, working in an organisation that employs diverse people, and job security.
The male students both reported examples of encouraging encounters (Q3) in which they made mistakes and learned from tradespeople of drafters. A male student’s identity evolved from a focus on technical computer identities as student engineers rather than engineering students (Q5). In contrast, examples of encouraging encounters (Q3) reported by female students included talking with recent graduates, having their work acknowledged, discovering that they felt they could do engineering, being offered graduate employment, and being told that their qualifications would be valuable for an engineering role. These were aligned with improving their self-efficacy and motivation for becoming engineers – confirming that they had the right skills and would be valued, and that engineering practice could be compatible with life (Q5).

Although male and female students reported predominantly positive experiences of exposure to engineering practice, within the sample we discovered male and female students’ concerns about disconcerting possible future roles (Q2). Two features that male and female students wished to avoid in possible future roles balanced the appealing features that they had identified; they feared lack of challenge and being restricted to limited career opportunities. Additionally, examples of features of unappealing futures identified by female students included living far from cities, working with tradespeople or technicians who might not respect them, long hours, high intensity, and competition. These are consistent with fears that engineering practice might be an environment in which a female engineer is not necessarily respected, does not have a job compatible with life, and must compete despite potential lack of respect. These concerns were consistent with and possibly arose from the disconcerting encounters reported by the female students.

We found examples of female students’ experiences of disconcerting encounters (Q4) consistent with the gendered workplace cultures that have previously been found to
marginalise female professional engineers in western countries (Q6). As a result, one female student doubted her long-term ambition to become an engineer and modified her enrolment (Q5).

The results support further investigation into the nature and impact of gendered workplace cultures into which engineering students are immersed. Without this understanding, educators will not know whether attempting to expose female students to engineering practice has the adverse effect of discouraging them from pursuing an engineering career, consequently undermining the many efforts to recruit these students to the profession.

Three additional recommendations are supported by this small pilot. First the study draws attention to the imperative that students reflect on their workplace experiences with others, consistent with recommendations for work integrated learning (Orrell, 2011).

Second, although the male students’ reports describe the excellent learning opportunity that can be provided by working with tradespeople, the female students’ reports reveal that workplace experiences in which engineering students hardly interact with engineers have potential to create doubt about working as an engineer. This needs further investigation.

Third, for male students in this study the exposure to engineering practice gained through a voluntary job in student motorsports provided much opportunity, not only to learn new skills, but also for identity development. Whether there is justification for such experiences to be given credit in degree programs should be investigated.

5. Acknowledgements

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6. References


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