Laws of Attraction: Increasing Female Interest in Engineering

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CONTEXT
Engineering outreach programs are common activities run by universities that aim to educate and enthuse prospective students about engineering. Despite outreach efforts, women remain vastly underrepresented in electrical engineering. It is possible that changes to traditional outreach programs to specifically target female incentives and misconceptions could increase female interest and enrolment in electrical engineering, and this will be investigated based on findings in relevant literature regarding the factors that have been found to influence female participation in engineering.

PURPOSE
The purpose of this research is to assess the effectiveness of targeted enhancements to an existing year 8 engineering outreach program, with the aim of increasing female interest in electrical engineering.

APPROACH
High school students attending the outreach program were separated into six groups of 50 students. Groups received slightly different variants of a starting presentation, based on factors considered to be significant in the literature. Qualitative surveys before and after the program indicated the impact of the program for increasing enthusiasm and eagerness for electrical engineering, and provided insights into the differences between females and males in terms of what may attract or deter them from electrical engineering.

RESULTS
Female participants indicated they were considerably more likely to pursue streams of chemical and environmental engineering than males. Both females and males were most strongly attracted to the hands on work in electrical engineering. Females indicated the next two most appealing aspects of electrical engineering were the challenge and teamwork. Females initially had less understanding of electrical engineering than males, and significantly less interest in pursuing electrical engineering, but the workshop significantly increased female interest in electrical engineering. The presentation emphasising socio-economic benefits of electrical engineering was most well received by all females, followed by the presentation providing insight into studying electrical engineering at university.

CONCLUSIONS
The findings supported prior research that females seem to have less awareness of what engineering is than males, but the outreach program effectively helped to narrow the gap between females and males, increasing female understanding and as a result increase female interest and likelihood to pursue engineering. The findings also reinforce that females seem more attracted to degrees and career paths where the social and environmental benefits are most evident. Outreach programs should attempt to emphasise the role of engineers in terms of the positive impacts to society and the environment engineers have in the modern world. Hands on work was the most enjoyable aspect of electrical engineering for both females and males in this context. The aspects of teamwork and challenging but achievable work appealed strongly particularly to female participants, who also responded positively to presentations about studying at university and examples of collaborative projects and social events. Whereas males were more attracted to the technical side and responded positively to presentations about the diverse options as an engineer and industry insights.

KEYWORDS
Outreach, women in engineering.

Introduction

Women are underrepresented in engineering. Electrical engineering is one of the specialisations of engineering with a particularly low proportion of females. The statistical update by Kaspura (2015) for Engineers Australia included statistics on the percentages of women in the engineering labour force in 2011 in the various streams of engineering. Overall, only 11.8% of the engineering labour force is women. The streams of engineering with the largest percentages of women are environmental engineering at 37.1%, biomedical engineering at 32.2% and chemical/process & resources engineering at 21.9%. This is a vast difference when compared to electrical engineering at 9.5%, mechanical engineering at 7.5%, civil engineering at 11.7% and aerospace engineering at 7.9%.

Many universities and organisations host outreach activities, to educate, enthuse and recruit prospective students. Engineering educators are often involved in these activities, helping to teach young females and males about the nature of engineering and perhaps inspiring them to pursue a path in engineering. However, the materials presented in outreach programs may not necessarily be marketed appropriately towards females. Research has previously been conducted with the intent to determine some of the reasons females may not choose to study engineering. Some of the major barriers that have been identified are:

- *Lack of understanding of what an engineer does:* During her research, Blaisdell (2000) found that "female high school students are often unaware of what engineering is", suggesting a lack of understanding of what an engineer does is a contributor to lack of female enrolment.
- *Unaware of the socio-economic benefits of engineering:* Sassner, Lineberry & Scheff (2004) claimed that females are unaware of the "human side of engineering" and "how engineers influence quality of life". Muller (2003) claims that this is of importance because females are more likely than males to pursue a field in what they believe will achieve societal good, and engineering is not commonly considered or realised to be one of these fields.
- *Belief that engineering is technical and isolating:* Interviews of high school students conducted by Kasarda, Brand, Weigand, Yochum and Collver (2010) following a pre-engineering high school program indicated that while male students are attracted to hands-on engagement, female students put significant emphasis on the positive social dynamic arising from team-based and goal-orientated class structure. Zywno, Gilbride & Gudz (2000) explain that engineering is often perceived as an overly technical and solitary pursuit. Sassner, Lineberry & Scheff (2004) also claim women think that engineering is a secluded profession with minimal human interaction. Frize & Eng (1989) also remark on the importance of human interaction to women, claiming that "women often enjoy the 'people side' of work, teamwork and writing". In addition, Thorn, Pickring & Thompson (2002) suggest women are drawn to careers they believe they will be supported in, and engineering is a technical career they perceive as having a lack of support.
- *Perception of difficulty:* Zwyno, Gilbride and Gudz (2000) claim engineering is perceived to be extremely difficult, and girls tend to choose something they believe is more achievable. Sassner, Lineberry & Scheff (2004) explain that girls have already begun losing confidence in their ability for maths and science by eighth grade, after which they may not pursue the subjects, which are required for entry into an engineering degree.

This study endeavoured to ascertain which attributes attract females to engineering, and the barriers that may deter them from pursuing it, with the intention of improving outreach programs and marketing materials to increase female interest in electrical engineering.

Methodology

Monash University recently conducted its second annual "Year 8 ChallENGe" (http://eng.monash.edu/challenge/) in 2016. The program was held on the university campus and involved approximately 300 year 8 high school students. Over three days, students participated in half day workshops, rotating between six streams of engineering – Chemical, Civil, Mechanical/Aerospace, Electrical, Environmental/Materials and Resources Engineering.

Students were invited to complete an anonymous, optional paper survey before commencing and after completing the electrical engineering workshop, to compare the change in perceptions of electrical engineering as a result of the workshop. The surveys included both qualitative questions and quantitative questions on a 7-point scale.

The electrical engineering session involved:

- a 15-minute presentation, of which there were four slightly different versions that emphasised different aspects of electrical engineering – these being:
    - A baseline presentation that introduced the various areas within electrical engineering which were introduced and explained in terms of an electrical engineer's role.
    - A presentation with a strong socioeconomic emphasis. This presentation was similar to the baseline presentation, but framed each of the discussed areas of electrical engineering in terms of how electrical engineers can positively benefit society and the environment.
    - A presentation that included experiences at university. This was the baseline presentation with the addition of university experiences.
    - A presentation including experiences in the industry. This was the baseline presentation with addition of experiences working as an electrical engineer.

- 45 minutes of tours of the department showcasing some of the laboratories with talks and demonstrations from postgraduates and academic staff.
- 2 hours of "hands-on" construction of a light-seeking Braitenberg robot called the 'Robomoth' which students kept for themselves.
- A total of 164 students returned the surveys, comprising of 37.2% females and 62.8% males. The students came from a wide range of schools in Melbourne, Australia, with 31.9% attending public schools, 41.2% independent, 24.4% catholic and 2.5% home schooled. The vast majority of students were of ages 13 or 14, and 89.7% of students specified English was their first language.

Results and discussion

Preferred streams of engineering

The participants were asked which stream(s) of engineering they were most likely to pursue in the pre-workshop survey. As indicated in Figure 1, there were clear differences between females and males. Females indicated they were considerably more likely to pursue streams of chemical and environmental engineering than males ($p < 0.05$). Females who selected chemical engineering frequently described it as "interesting", and many expressed that their "interest in chemistry and science in general" as the reasoning behind their selection. These same themes arose for females who selected environmental engineering, along with the fact it is the most "useful" due to the socio-economic benefits, with females explaining their desire to: "help improve society", "look after the environment" and "preserve unique nature and wildlife". These results were consistent with the findings of Kaspura in the Engineers

Australia statistical update, in which environmental, chemical and resources engineering were much more popular for females in comparison with electrical and mechanical.

Males on the other hand expressed a significantly higher interest in electrical engineering than females ($p < 0.05$) before the workshop.

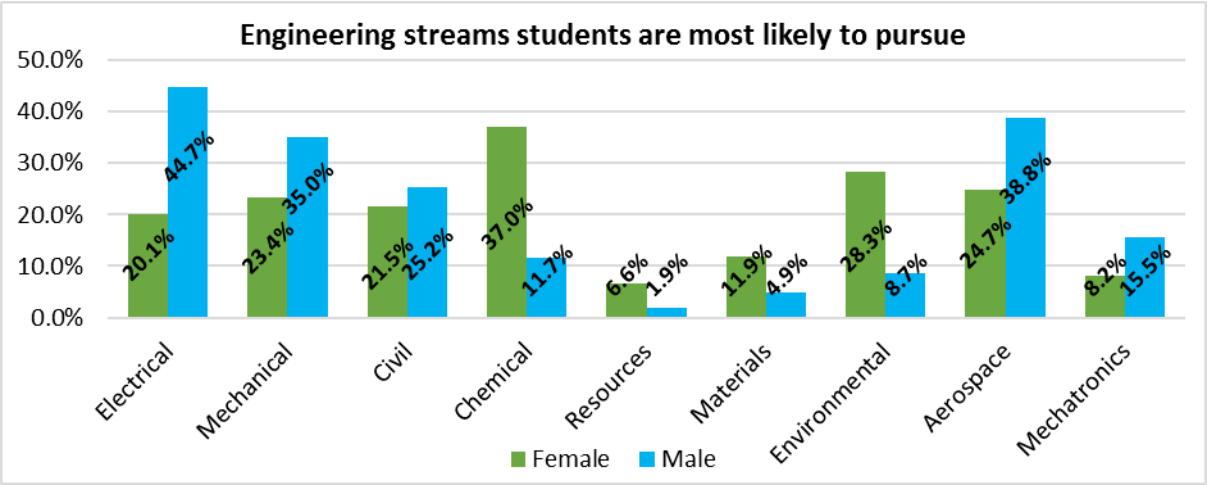

Figure 1: Engineering streams students most likely to pursue

Attractive and discouraging features of electrical engineering

Students were asked in the post-workshop survey to choose up to 3 of 9 different aspects of electrical engineering of aspects that appeal to them, and similarly up to 3 of the same 9 aspects that might that deter them from pursuing electrical engineering, with results shown in Figure 2.

Females and males had similar thoughts on the mathematical nature of electrical engineering. Whilst many were attracted to this aspect of electrical engineering, many were also deterred by it.

One clear distinction was that males were much more attracted to the technical aspect of electrical engineering than females ($p < 0.05$). The fact that electrical engineering is perceived as “technical” was the second biggest attraction to males and attracted the majority of males, but only a third of females. It was a deterrent for almost double the percentage of females than males.

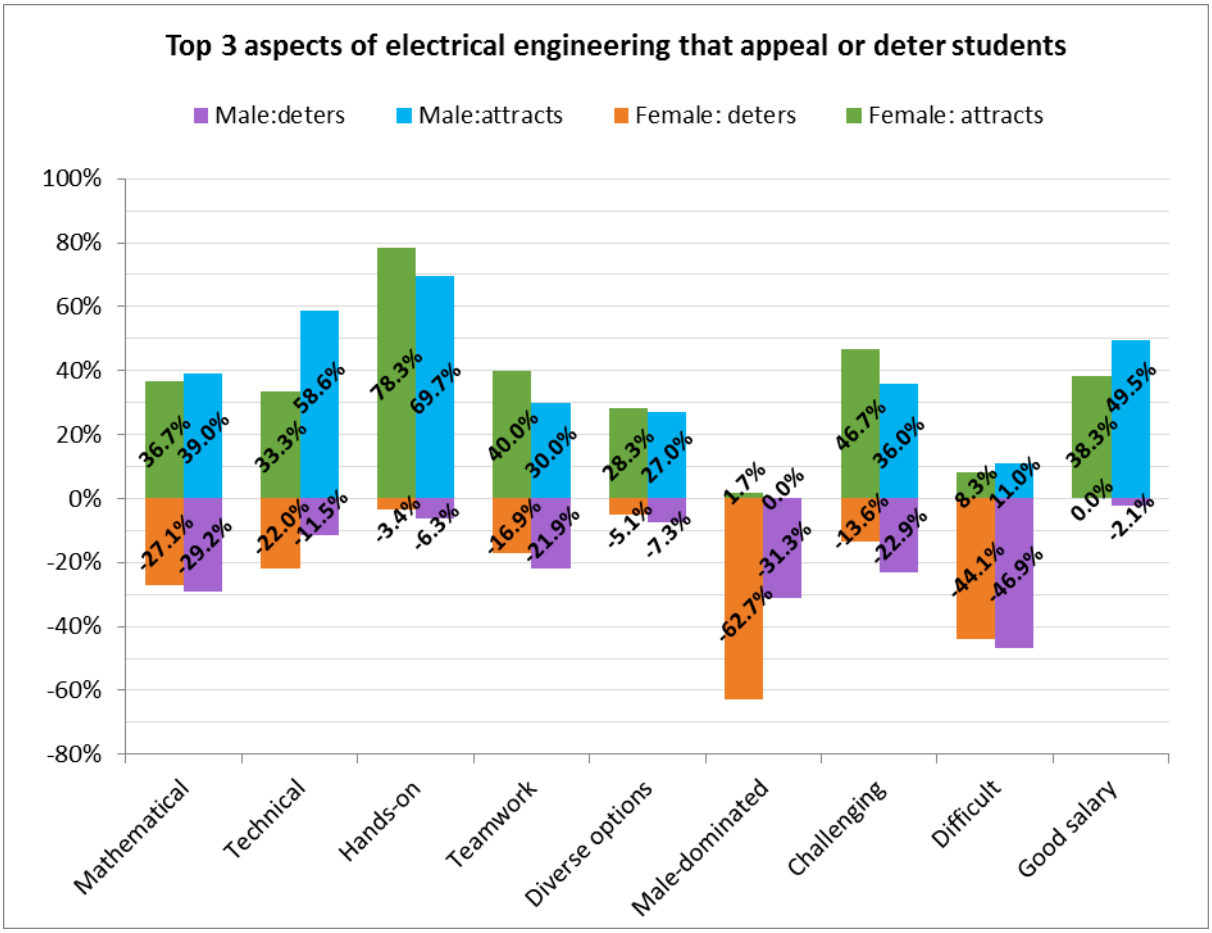

Figure 2: Top 3 aspects of electrical engineering that appeal or deter students

Interestingly, both females and males expressed that the “hands-on” aspect was their highest favoured aspect of electrical engineering, and that females were just as attracted to the hands-on aspect as males were. Predominantly, the comments supported this, with most students expressing that they enjoyed building the robot.

Learning about the prevalence of teamwork in electrical engineering acted as an attraction for many females, with the majority of comments favouring teamwork coming from females: *“it is fun to work as a team”*, *“I really enjoy working in teams so electrical engineering is more appealing”*, *“I have found out that electrical engineering involves team work so it is much more appealing”*, *“more people are able to make a better finished product than just one person making it”*, *“can learn new things from others”*.

Unsurprisingly, the fact that electrical engineering is male dominated was the major deterrent for the majority of females in considering to pursue electrical engineering. Females expressed many concerns regarding this: *“I want to be in a workplace with females”*, *“it’s hard to learn without any role models of your gender”*, *“I like working with girls as well as boys”*, *“[I] won’t be treated with the same amount of respect”*, *“many might view it as strange to pursue [electrical engineering]”*.

Apart from hands-on aspect, the most favourable aspect of electrical engineering to females was the “challenging" nature of the work. Students made the distinction between ‘challenging’ and ‘difficult’ – they tended to enjoy the thought of testing their abilities, but unsurprisingly wanted it to be achievable and not too hard, hence were deterred by the difficulty. Interestingly, both females and males appear equally deterred by the difficulty of electrical engineering, and as seen in Figure 3, have an equal perception of the difficulty of engineering.

Students were also asked in the pre-workshop survey to rank on a 7-point scale the importance of job salary to them. The mean for females was 5.30, whereas the mean for males was 5.78, a difference that is statistically significant ($p < 0.05$). Hence, salary appears to be slightly more important to males. This result is further indicated in Figure 2, with both females and males nominating "good salary" was an attracting feature of electrical engineering, but more so to males.

Effect of the workshop

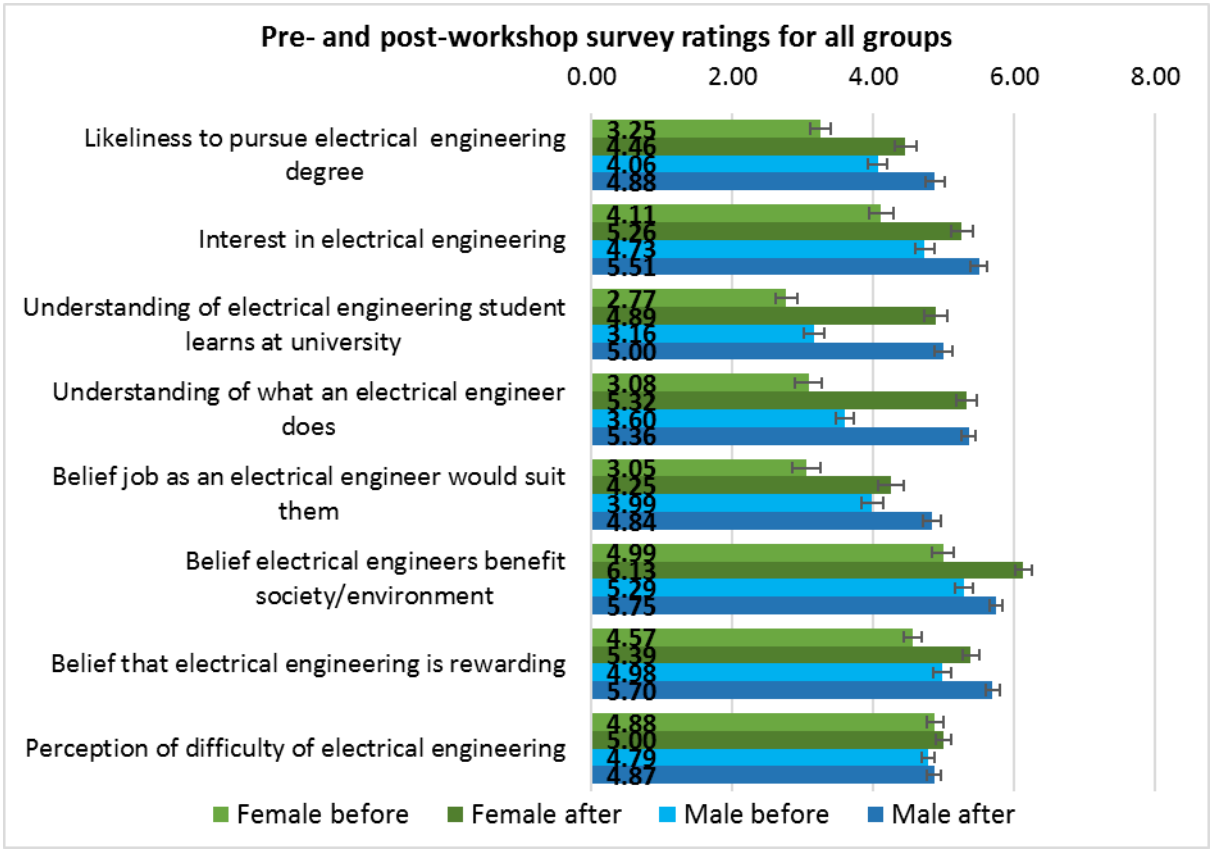

Figure 3: Pre- and post-workshop survey ratings for all groups

There were eight questions answered on a 7-point scale which were present in both the pre-workshop survey and post-workshop survey. This provided a quantitative measure of how different attitudes towards electrical engineering changed as a result of the workshop as shown in Figure 3, where error bars indicate the standard error of the mean.

Before the workshop, males were much more likely to pursue electrical engineering than females, as shown by a difference of 0.81 on the 7-point scale ($p < 0.05$). However, as a result of the session, females had a dramatic increase of 1.37, and so after the workshop, although males were still more likely to pursue electrical engineering than females, the difference was now only 0.42 between males and females. The results were similar for overall interest in electrical engineering. Although females were less interested in electrical engineering than males before the session, after the session females and males shared similar interest levels.

Females indicated they had less understanding of what an electrical engineer does than males before the session ($p < 0.05$). And, by the end of the workshop, they shared equal understanding with males on what an electrical engineering student learns at university and what an electrical engineer does.

Most notably, females had a much lower belief a job as an electrical engineer would suit them than males, with a difference of 0.94 ($p < 0.05$). As a result of the session, females now

believed they may be more suited to electrical engineering, with an increase of 1.2 in their ratings.

Interestingly, both females and males shared similar beliefs on how electrical engineers can "benefit society and the environment" before the workshop. After the workshop, however, females had a large increase in how strongly they believed *"*electrical engineering can have socio-economic benefits*"*, which was much stronger than males. This may indicate females are more receptive to socio-economic impacts. Some comments by females indicated this was an important factor for them in their interest for electrical engineering. Before the session, one student commented *"I am slightly interested in electrical engineering because I believe that it is important but not vital enough to be placed as a priority."* After the workshop however, when asked if there was anything that they learnt that attracted them to electrical engineering, the student responded *"I found out how electrical engineering could benefit society through robotics."* A different student who was most attracted to environmental engineering before the session, commented after the session that *"learning about how much electrical engineers impact society really changed my mind about engineering."*

There was no statistically significant change in the perception of difficulty of electrical engineering as a result of the workshop. It appears that both females and males more or less had an equal perception of the difficulty of electrical engineering.

Effect of various presentation methods

Pre- and post-workshop survey data has been compared between the different variants of presentations as shown in Figure 4 for females and Figure 5 for males. Small sample sizes in each of the groups receiving the presentation, particularly for females, moderates the strength of our findings in terms of the generalisations that can be made. The other confounding factor was that the base presentation may not be the most accurate baseline as it was the very first workshop of the program, when students hadn't seen any other streams of engineering yet, and hence may have been more in wonder – especially for females who may be having their first ever introduction to engineering and having misconceptions dispelled. However, the gathered data remains interesting nonetheless.

The presentation with socio-economic emphasis provided the highest rating for female likelihood to pursue electrical engineering as shown in Figure 4. It also resulted in the highest rating for female belief they would be suited to a job as an electrical engineer, as well as belief that electrical engineering is rewarding. The socio-economic presentation was also effective for males, also resulting in the highest likelihood to pursue electrical engineering for males and belief the job would suit them as shown in Figure 5. Overall, this presentation was universally the most well received. This presentation expressed the many elements of electrical engineering that were presented in the base presentation in terms of how they could positively benefit society and the environment, as well as discussing modern challenges electrical engineers are facing to provide a sense that electrical engineering is still relevant and a necessity for the world. Since this presentation provided better outcomes across all categories for both females and males than the base presentation, explaining socio-economic benefits may be an effective method of generating more interest in engineering for males and females alike.

The presentation including university experiences was well received by females, generating the greatest interest in electrical engineering in the post-workshop survey and was close behind the socio-economic presentation in the other categories in Figure 4. This presentation was not as effective for males when compared to the socio-economic and industry presentations as seen in Figure 5. This presentation had images, videos and animations of various group design projects that students completing electrical engineering could work on, emphasising teamwork and creativity. It also discussed the many social events at university, including images of many girls doing engineering, along with workshops and career events. This presentation may have been particularly effective for females because it provided

imagery of females in engineering, and was in fact presented by a female, attempting to alleviate fears of a male-dominated cohort. 92% of the females in the group receiving this presentation liked the hands-on aspect of electrical engineering, and 77% commented that they enjoyed the robotics element of electrical engineering, an element that was heavily featured in the presentation. The prominence of hands-on work when combined with a heavy emphasis on teamwork and creativity appears to have been particularly effective for females, and less so for males.

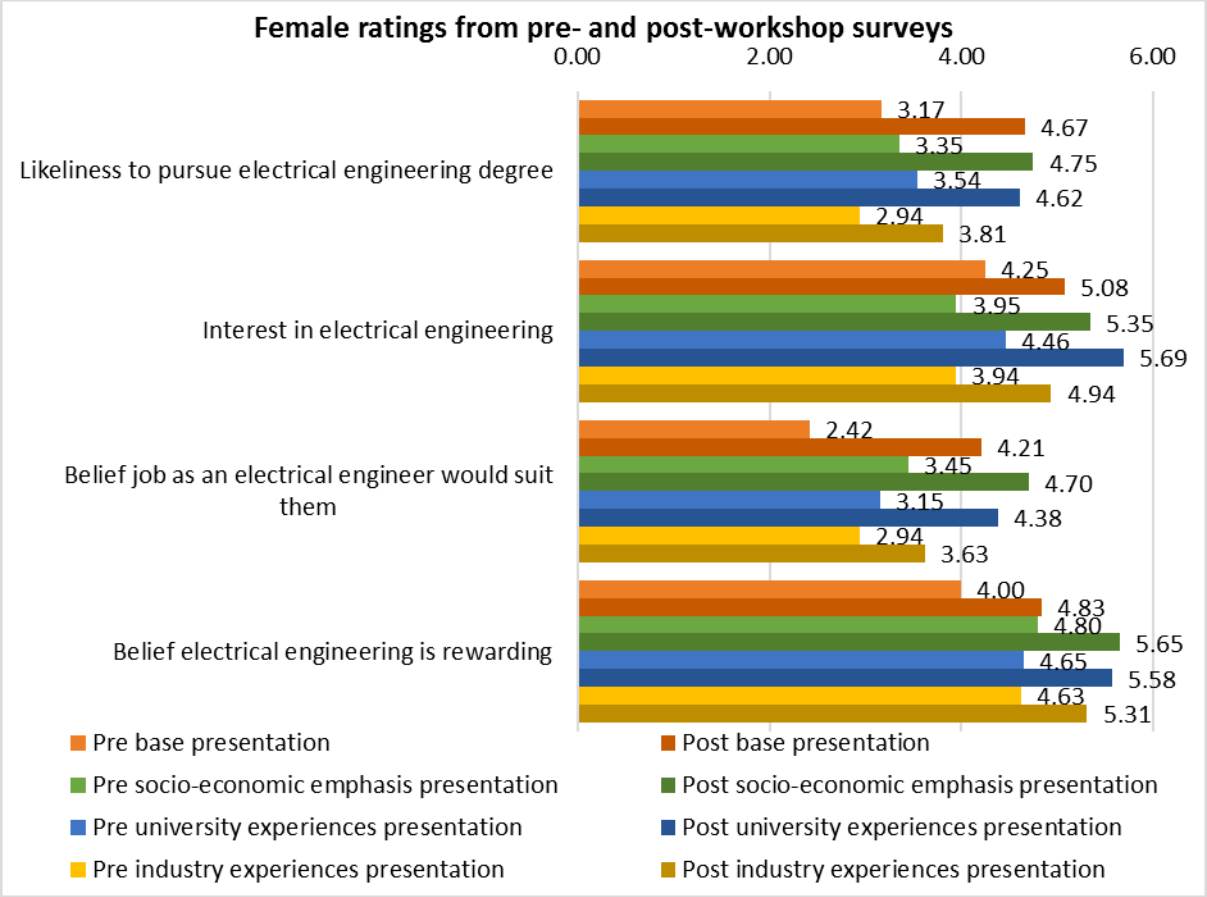

Figure 4: Female ratings from pre- and post-workshop surveys

The industry experiences presentation appears to have been the least effective in terms of improving female interest and likelihood to pursue electrical engineering, and beliefs that it is a rewarding job and that they may be suited to it. Interestingly, by comparison, this presentation was much more effective for males, and virtually on par with their ratings for the socio-economic presentation, as well as giving the highest ratings for interest in electrical engineering and belief electrical engineering is rewarding for males. The industry experiences presentation expressed that engineering is in many ways a degree on solving problems, whether that be for a technical role, pursuing research, or perhaps more commonly project manager type roles. The presentation also discussed the teamwork nature of the job, communication and reporting required, support networks and salary. Males who received this presentation expressed that they enjoyed the diversity of electrical engineering, the good salary, the thinking involved and the teamwork. It is possible that females were not as attracted to this presentation because it made electrical engineering seem overly technical.

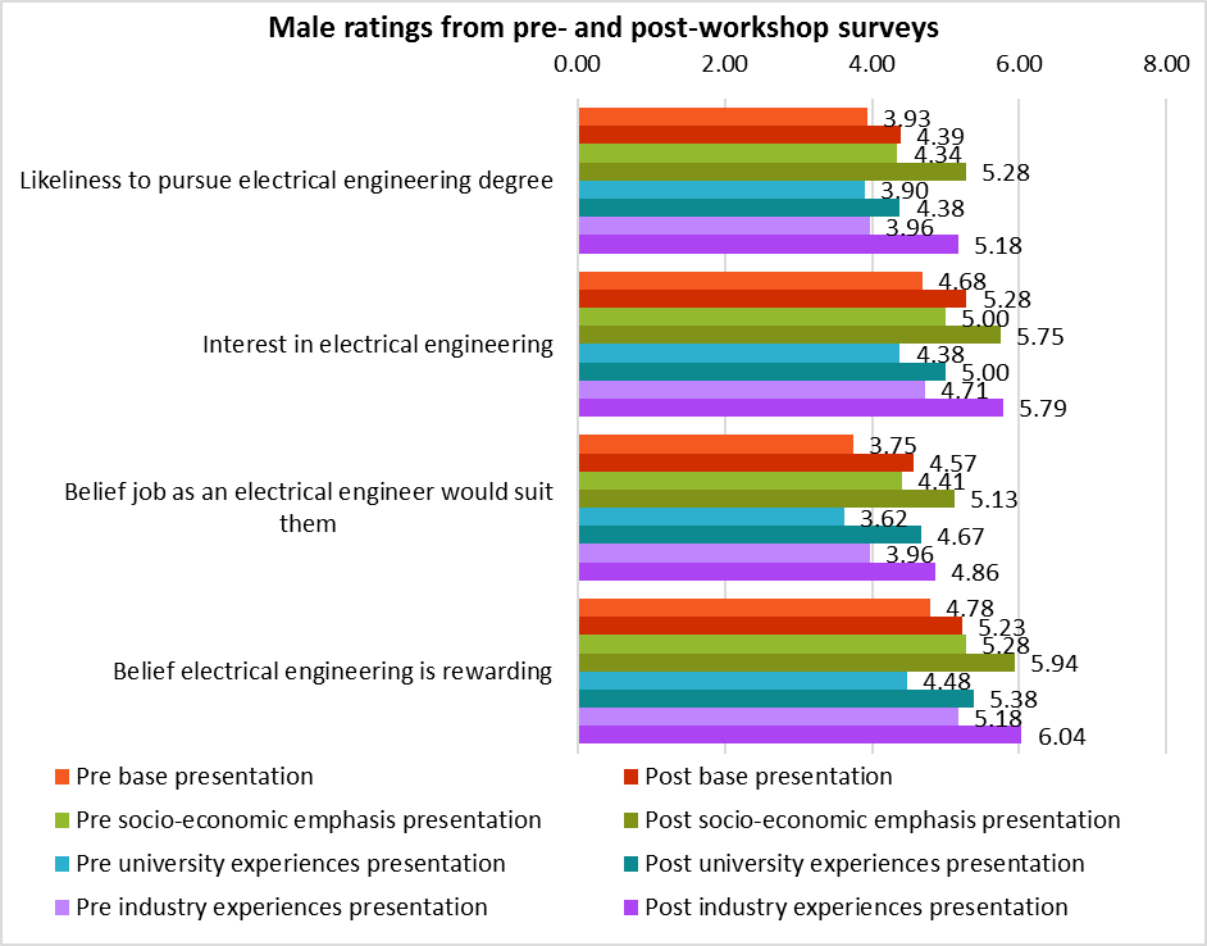

Figure 5: Male ratings from pre- and post-workshop surveys

Conclusion

There are some distinct differences between females and males that should be taken into consideration when creating outreach materials and programs. Our data reinforces previous findings from the statistical update by Kaspura (2015) for Engineers Australia that females are more attracted to streams like chemical and environmental engineering. The presentation that presented electrical engineering in the context of societal impact was very effective for improving perceptions of electrical engineering for both females and males, and several female participants expressed that this was a major factor that influenced their thoughts on electrical engineering, supporting prior research. Hence, outreach programs about other streams of engineering should try and emphasise how their work can have significant positive impact on the society and the environment.

The results of our study indicate that for this context, both males and females especially enjoy the hands-on aspect of engineering, hence this should be emphasised with outreach efforts in similar contexts. Teamwork appealed strongly particularly to females, who also responded more positively to presentations about studying at university and examples of collaborative projects and social events. Whereas males were more attracted to the technical side and responded more positively to presentations about the diverse options as an engineer and industry insights. To try and offset the perception of engineering being male-dominated, outreach efforts should try and include females as presenters and in photographic marketing materials, as the lack of females was the greatest deterrent by far. Employability and salary is a point that may be highlighted, as this was an attraction to females and males alike. In general, students like the fact that electrical engineering is

challenging, but do not want it to be too difficult. Hence, engineering should be presented as something that perhaps demanding, but also achievable and rewarding.

Overall, the results indicate that before the outreach program, females were less interested and less likely to pursue electrical engineering than males. This may be attributed to their lack of understanding of what an electrical engineer does, which they indicated was less than that of the males before the workshop. As a result of the workshop and learning about electrical engineering, females were significantly more interested in electrical engineering and more likely to pursue electrical engineering, and had equal understanding to that of the males. The results indicate that the outreach program is likely to be an effective tool to 'narrow the gap' between females and males in electrical engineering. In general, males may have gained greater exposure to electrical engineering than females; but once females have learnt about electrical engineering, they may be more likely to pursue it. This emphasises the need to target females in outreach efforts about engineering, as perhaps their lack of awareness may be the biggest barrier of all.

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