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## **Exploring Women's Experiences of Choosing and Studying Engineering and Navigation: A Case Study**

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### **ABSTRACT**

Women remain underrepresented in UK engineering, constituting only 11% of the engineering workforce in 2017 (WISE, 2017). This paper summarises the findings from two focus groups. From a total of 12 participants, the groups explored the experiences of undergraduate women engineering and navigation students at the University of Plymouth. Our aim was to identify ways in which we might support the recruitment, retention, and advancement of women in these disciplines. By identifying common experiences, it was possible to illustrate how women as a group experience engineering and navigation differently to men. Our findings support those of many other studies and include the "non-visibility" of engineering as a career option for girls and women, and the need to adopt a range of strategies in order to fit in and claim an authentic identity as an engineer, rather than a "woman engineer." Participants were sceptical about initiatives overtly contrived towards helping women to progress in the disciplines, as these can be perceived as constituting a form of positive discrimination against male students with the added concern that male students view them as such. Future research and possible initiatives are discussed.

### **KEYWORDS**

Engineering; navigation; gender; student experiences; underrepresentation

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### **INTRODUCTION**

Engineering careers are potentially highly diverse, rewarding and desirable, yet women remain underrepresented in UK engineering, constituting only 11% of the engineering workforce in 2017 (WISE, 2017). This is lower than all other EU countries (European Commission, 2007). This figure is even lower at under 5% for navigation and maritime science. The navigation and maritime science programme offers a route to becoming a professional seafarer in charge of ships, or to work in the shore side maritime sector. At Plymouth, around 10% of the students in navigation and maritime science are female, which is above the national average (UoP, 2017). These statistics show that in the last 40 years, efforts to improve the gender profile in engineering have yielded limited success, whilst in navigation, efforts to increase female participation have only recently begun.

Although women remain underrepresented in engineering at all levels, the recruitment, retention, and progression of women undertaking engineering degrees is critical for developing the pipeline of talent for the future. This issue has been recognised by the Royal Academy of Engineers (RAEng) which, in the last six years, has undertaken diversity work (RAEng, 2014, 2017, 2018) and is actively promoting engineering to women. Whilst this is encouraging for female students, it remains true that many often have to endure a generally "chilly" environment (Flam, 1991) and subsequent feelings of non-belonging (Walton & Cohen, 2007), both of which can lead to negative wellbeing outcomes (Cohen, Garcia, Purdie-Vaughns, Apfel, & Brzustoski, 2009). This potentially results in a situation in which women, whilst succeeding, are doing so at a cost. These negative factors perhaps offer an insight into why large numbers of women continue to be discouraged from pursuing an engineering career.

A focus group methodology was employed to capture the experiences of current female students and gauge their attitudes towards engineering and gender. It was our hypothesis that gender would be an important shaping factor in the participants' experiences of engineering in higher education and beyond. This case study presents the literature review, method and data collection procedure, and results, followed by our conclusions and recommendations.

### **LITERATURE REVIEW**

Female underrepresentation in engineering has been well documented. Efforts to increase the percentage of women in engineering and STEM go back over 30 years, with the inception of WISE in 1983, and as a campaign in 1984. However, numerous subsequent initiatives, both from the Royal Academy of Engineering (RAEng) society and other STEM activities, have failed to increase the percentage of females choosing engineering.

Research has highlighted not only that STEM subjects can be perceived as difficult to learn (Hulme & de Wilde, 2015, p. 6), but also the difficulty of transitioning

between school to higher education (Wakeling & Hampde-Thompson, 2013). Whilst, other studies have found that women are primarily attracted to STEM fields that they believe will allow them to help others and benefit society (Freund, Weiss, & Wiese, 2013). Hence women are more likely to choose biomedical and environmental engineering than mechanical or electrical engineering (Ceci & Williams, 2011). Women also place a higher priority on caring responsibilities, for which they are willing to make occupational sacrifices (Eccles, Barber, & Jozefowicz, 1999; Hakim, 2006; Hill, Corbett, & Rose, 2010). Traditionally, engineering employers have shown resistance towards flexible working, which has had a disproportionate impact on the retention of women in these fields (WISE, 2017).

In addition to the points highlighted above, studies by Meyer, Cimpian, and Leslie (2015) suggest that success in STEM subjects is believed to require intelligence and talent, which is set against the cultural stereotype that women have lower ability in mathematics (Bench, Lench, Liew, Miner, & Flores, 2015; Luong & Knobloch-Westerwick, 2017; Rea, 2015), again posing a barrier to the success of women in these fields. Despite a number of efforts to redress the gender balance within engineering, the field remains male-dominated (Thackeray, 2016), which is again seen as a barrier to women. Further, for women who do choose engineering, classroom experiences can, on numerous levels, serve as a barrier towards career progression and retention. Not only do women feel that they have to adapt themselves to a traditionally masculine culture (Baxter, 2010), but they also have to work harder to establish their scientific authority (Smith, Lewis, Hawthorne, & Hodges, 2013). Thus, women can feel demoralised in an overtly competitive environment (Shedlosky-Shoemaker & Fautch, 2015), resulting in their suffering from imposter syndrome—one characterised by “persistent thoughts of intellectual phoniness” (Hutchins & Rainbolt, 2016, p. 194) and eventual changes in direction. A study by Ellis, Fosdick and Rasmussen (2016) suggests that after taking Calculus I, women are 1.5 times more likely to switch to a non-STEM field compared to their male counterparts with the same level of preparation.

Research into the experiences of women in the maritime industry is still in its early stages. However, Mackenzie (2015), looking at the challenges faced by women in this sector, reveals how the issues are exacerbated due to the need to work offshore or on board ships. Additionally, the female role models that do exist in the maritime sector have often compromised by not having a family or by becoming “one of the boys” in order to achieve high-level positions. This is counterproductive, as it reinforces perceptions of the maritime industry as unsuitable for women. More recent work presented by Bhirugnath-Bhookun and Kitada (2017) suggests that male ex-seafarers, who often occupy managerial positions, are not used to working with women and can be overtly discriminating towards them.

Interestingly, the above issues also apply to the engineering sector, despite the numerous campaigns aimed at challenging the underrepresentation of women. According to WISE (2017), girls make their choices based on the career opportunities that studying a STEM subject will offer. Therefore, in order to increase female recruitment in engineering, it is vital that they are aware of the

career opportunities it offers, as well as the flexible working conditions that are beginning to emerge within engineering and navigation careers.

### **METHOD AND DATA COLLECTION PROCEDURE**

In order to gain an understanding of their choices and experiences, we conducted focus groups with female undergraduate engineering and navigation students. The advantage of the focus group method was that it facilitated interaction, allowing for the sharing of experiences and views. This approach can, for example, generate conversation and thus raise topics and ideas that might not necessarily arise in a one-to-one interview (Bryman, 2012). A limitation is the sample size. Therefore, we should treat the results with caution.

The project received ethical approval from the Faculty Human Research Ethics Committee. Sixteen female students initially volunteered, with 12 eventually participating in the two focus groups. The first group comprised civil engineering students, whilst the second was predominantly made up of mechanical engineering students, although also including one navigation student. All students were in their third year of study and some had completed an industrial placement year. The duration of the focus groups was approximately one and a half to two hours. Each focus group was co-ordinated by two facilitators and a scribe—two women and one man. The focus groups were recorded (audio only) and transcribed verbatim. All of the participants were briefed and then asked to sign a consent form informing them that they could leave at any time during the process. The focus group questions concentrated on why women had chosen engineering or navigation, and explored their experiences in the School of Engineering at the University of Plymouth.

### **RESULTS**

The focus group data were analysed using a thematic approach. A number of themes emerged from the responses, which were grouped according to their relationship to (1) choice of degree subject and (2) the experience of studying it.

#### **Choice of Degree Subject**

The group interviews began by asking the participants what had led them to choose to study engineering (and in one case, navigation). It was possible to identify common themes that had either constrained or enabled their choices. Barriers included the “invisibility” of engineering as a study and career option for girls; a lack of positive encouragement to consider engineering; the belief that engineering is only for high achievers in mathematics; and reactions from others confirming the view that engineering is not a conventional choice for girls.

#### *Awareness of engineering and navigation*

Many of the participants said they had chosen engineering because of their aptitude for science and mathematics, and thus they found it to be a discipline that combined these interests. However, the majority of participants agreed that engineering had not been presented to them as an option to which to aspire whilst at school. Several of the participants mentioned that their choice for engineering was made at a very late stage in the university application process. In some cases, this was expressed as coming to engineering almost by accident and chance:

I saw a prospectus in the library in my new school and found engineering there. You don't even know it [engineering] is a thing that exists! (Participant 1, mechanical engineering student)

For this reason, most participants agreed that more should be done in schools to raise awareness of engineering and the school subjects needed to access the field in higher education.

#### *The image of engineering*

Many participants agreed that most people are not sure what an engineer does—there is, for example, a common misperception that an engineer is a car mechanic:

But no-one really understood what an engineer was either. So, I still remember one of the girls [was] like "oh what are you doing when you leave?" I was like: "Oh I'm going to uni, I'm going to study mechanical engineering" and she was like "so you're going to fix cars and stuff?" I was like "not really," I'm like: "I'm more likely to be designing them than fixing them, but sure, whatever!" So they didn't understand what I was doing at all. (Participant 1, mechanical engineering student)

Conversely, some participants mentioned that engineering is perceived as a "difficult" subject to get into—particularly because of the belief that you need to be a high achiever in mathematics.

#### *Familial encouragement*

However, several of the participants had relatives who were engineers or had some connection to engineering. In most of these cases, they had often been encouraged to consider engineering:

Actually it was my mum. She said if she had her time again, she'd go and be an engineer. And I found that... I was like: "well what is engineering then?" So yeah, [I] looked into it and thought actually this could be quite interesting. (Participant 2, mechanical engineering student)

#### *An inauthentic choice for girls?*

Some of the women had faced reactions from others regarding their choice of A-levels or degrees—sometimes surprise, sometimes bemusement—which served to remind them that their choice is atypical:

I was met with surprise when I picked maths and physics A level, [it] doesn't seem natural. In a way it's nice, 'cause people are impressed. But it shouldn't be any different. (Participant 3, civil engineering student)

### **Experiences of Studying the Degree**

Generally, participants talked in positive terms about their study experiences. Most participants agreed that they have equal status with men on their degree and that there is no difference in the way the sexes are treated. However, several themes emerged that portrayed a challenging learning environment for female students.

Key amongst these was the belief that male students feel threatened by women on the course; the necessity for women to earn credibility; and the costs faced by women as a result of positive action measures.

#### *Confidence and competition*

There was a high level of agreement that male students tend to be more confident in their abilities than female students, and that the men feel a need to demonstrate their superiority:

Yeah, they do, they think they're more superior. And they, like I had a group... there was 7-8 of us in the design module and it was brutal for me. I absolutely hated it, and I just felt this big... I was like I'm good at design and you lot are just making it... it was hellish, it stripped all your confidence and it makes you feel like "I just don't belong here—shall I choose something else?" (Participant 2, mechanical engineering student)

#### *Proving yourself*

The fact that many male students appear to rate their abilities more highly than their female peers intensifies the additional effort that women must make in order to prove their right to be on the degree and in so doing, "earn" their place. One participant, who is older than most of her peers, described her experience of working with her younger, all-male group as follows:

One of the boys was talking to me but he didn't think I could bring anything much to the party, but I brought a prototype and my design and he was like "well if you've done all that, let's do that." I did spend the rest of [the] time organising them and they were perfectly happy to be organised. But then I'm older and they're younger, so there's probably that imbalance too and I'm maybe a bit more organised naturally. (Participant 4, civil engineering student)

#### *Tolerating banter*

Robnett (2016) has described how women respond to gender discrimination perpetrated by their male peers. Responses range from active, to passive coping. Whereas active coping might involve reporting an incident, passive coping involves accepting it, or denying that the behaviour constitutes discrimination. The passive coping response is reflected (below) in the idea that "banter" must be tolerated:

The guys come out with stuff that I just know they're just being sarcastic 'cos they try to get a reaction out of me. They know... they're starting to learn now that I just won't bite... that prepares me for anything anyone else has got to say... It is just pure banter. They treat everyone the same. They pick on each other... They can say something about me being the only girl, but they're not getting the reaction they want. Not had any serious discrimination. (Participant 1, mechanical engineering student)

*Positive action backlash*

On the question of tackling gender imbalances in engineering, most participants supported the idea of actively encouraging schoolgirls to consider choosing “non-traditional” subjects at A-level and beyond. However, many agreed that once they have reached the university stage, women have parity with men, or sometimes even an added advantage, and therefore, extra support is not needed:

I think the outreach is a good thing, . . . [acting as] STEM ambassadors, potentially going out to schools and encourage girls in to engineering, I think that’s good... I think we all expect to have to measure up... I know they might look at your CV twice, but you’d like to hope that you’ve got to be as good as the male applicant to get the job... I don’t think any of us would want to be handed it on a plate would we? (Participant 5, civil engineering student)

A widely held view was that women’s “unfair advantage” is particularly visible when students are being selected for industrial placements and graduate jobs.

*The desire to be accepted as an “authentic” engineer*

For many participants it seems that initiatives such as the Women Engineering Society are perceived to be at odds with the need to fit in and be the same as everybody else. The desire to be accepted simply as an engineer, and not as a “woman engineer,” was frequently expressed, as was the need to receive placements or jobs on merit:

You’re like... “I don’t want to be looked at because I’m a woman in engineering, I just want to be looked at as an engineer.” So it’s definitely something you get a lot of... “Oh you’ll be fine, you’re a woman.” You’re like “OK.” (Participant 6, civil engineering student)

Even though there was a consensus amongst participants that they wanted to be accepted as engineers, and not as “women engineers.” As Faulkner (2006) points out, women can be sexually visible—i.e., they have to routinely establish their engineering credentials in a way that men do not—which can be costly to women engineers.

**CONCLUSION AND RECOMMENDATIONS**

Our findings show that a long history of outreach and support initiatives has enjoyed only limited success in increasing female participation and progression in engineering. Schools are not necessarily giving girls the opportunity to find out about engineering and navigation options. Those women who do become engineering students feel the need to gain credibility and make compromises in order to “fit in.” Positive action initiatives and support networks have had limited impact on the underlying gendered culture of these disciplines. Furthermore, women are discouraged from participating in “women’s initiatives,” because they are seen to give them an unfair advantage or imply that women need extra help. The perception that such initiatives are discriminatory or “anti-men” leaves women no basis on which to act collectively, or even in partnership with men, however, without positive action, nothing changes.

If we are to find a way forward, we must further explore student perspectives. In our future work, we will be conducting male-only focus groups in addition to female-only focus groups. We will also be piloting an equality, diversity, and inclusion committee for undergraduates, encouraging equal male/female representation.

Future equality initiatives must be sensitive to the unintended consequences noted here. One avenue for further exploration is to articulate a role for men in promoting gender equality. Men need to be included in promoting equal opportunities, and both men and women need to be aware of why it is still necessary to take positive action to bring more women into the engineering and navigation professions.

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