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Editorial: Gender and Intersectionality in Engineering

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This Special Issue is dedicated in memory of

Dr Jan Harding and Professor Ann Denis

Editorial: Gender and Intersectionality in Engineering

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This Special Issue of the "International Journal of Gender, Science and Technology" focuses on the issue of gender, and of how gender intersects with other aspects of diversity, in engineering. Published in 2019 in celebration of the 100th anniversary of the Women's Engineering Society, and to coincide with the International Women in Engineering Day on 23rd June, we have brought together some of the latest work on this critical area, from multiple perspectives and contexts, and from across the globe.

Our call for papers asked for: research into gendered experiences of higher education; explorations of the relationship between cultural norms and subject choices at school, and the career choices these led to; insights into the elements that have historically limited diversity within engineering; discussions of the 'leaky pipeline' and increasing lack of diversity at leadership level; and comparisons between engineering and other disciplines, or between engineering in different countries, in order to understand better how culture effects diversity. It is 30 years since Crenshaw (1989) introduced the term 'intersectionality' to describe the additional effects of multiple 'minority' characteristics, and we were looking to understand how this affects women in engineering. As well as rigorous research we were also interested in publishing shorter case studies of individual initiatives within education settings and industry.

Our call produced a great deal of interest, and from the large number of abstracts received we have chosen twelve papers to publish in this special issue. Our aim for a wide coverage of topics and for a global spread were partly successful, with some caveats. We received papers from Australia and Brazil, and one from India with a global perspective, but almost half of the papers published are from North America, with three from the US and two from Canada, and four came from the UK.

While the editors and journal being based in the UK may explain the last of these, we hypothesise that the dominance of American papers may reflect the fact that gender is seen as an important and possibly better-funded focus for research there. The final paper which compares data from across the world, goes some way to filling the gap in evidence from other countries.

One issue however that is not covered as well as we had hoped is the impact of intersectional considerations, suggesting that there is more work to be done in this area. Three of the papers have some focus on gender and race, while the final paper stresses the importance of the socioeconomic-political factors in working out which initiatives might work in different national contexts. However while mentioned by some in passing, there were no papers considering the intersecting impacts of disability, or sexuality, or to any great extent of socio-economic background. We will return to this in our conclusions.

This editorial considers the papers in turn, then draws a number of conclusions from the set as a whole. The structure follows approximately the career progression of an engineer, starting with the interventions and encouragement of girls to take STEM subjects, through undergraduate experiences, to working cultures in higher education and finally gender diversity and working cultures in industry

ENCOURAGEMENT INTO ENGINEERING

The first two papers discuss ways in which girls might be encouraged into STEM subjects. Concerns include both the perceptions of teachers and parents considering girls as less likely to be suitable to STEM careers and the perceptions of girls about themselves. In *Re-Engineering the "Leaky Pipeline" Metaphor: Diversifying the Pool by Teaching STEM "by Stealth",* Petray and colleagues write about the lessons learnt from running two drone-flying camps with girls aged 10 to 16 in northern Australia. The premise of the paper is that such non-STEM-specific activities might succeed in attracting girls who would otherwise not see themselves as the 'STEM type'. The analysis is based on pre- and post- camp questionnaires. Some participants also identified as coming from Aboriginal or Torres Strait Islander cultural backgrounds, groups which are very under-represented in STEM fields. An important aspect of this approach was that almost half of the participants identified their favourite school subject as arts or humanities rather than science. The authors suggest that standard interventions which focus on targeting young people who already excel in STEM subjects may in fact be acting to 'inadvertently exclude an entire cohort of students who think creatively and enjoy problem-solving, and are thus potentially good engineers, yet who do not necessarily identify themselves as the "STEM type."' The authors also note the success of the camps in attracting a high percentage of Aboriginal or Torres Strait Islander girls, who face multiple stereotyping dissuading them from STEM careers, and they suggest that engineering should recruit from a wider base of applicants 'that recognises and values the dispositions generated through engagement with creative and critical curricula.'

Ontario Network of Women in Engineering Case Study: Indicators of Success and Reflections on Lessons Learned by Wells, Jones and Davidson is a detailed case study of a much larger programme, the Ontario Network of Women in Engineering (ONWiE) in Canada. The authors are current and previous chairs of the network, a partnership between 16 university schools and faculties of Engineering and Applied Science in Ontario, which has run a number of initiatives since its start in 2005. These initiatives include an annual one-day event for girls between 12-16 years, Girl Guide (8-11 years) and Pathfinder (12-14 years) badges in technology, science and engineering, and Go CODE Girl, encouraging girls into software and computer engineering. The authors report that over 28,000 girls have participated in the programmes since the inception of ONWiE. While it is difficult to prove causation, there are various indicators of the success of the programme, including perhaps most notably a considerable increase in the percentage of women applying to study engineering in Ontario, from 16% in 2005 to 25% in 2018. The authors note that an important element in the

success of the project is the ongoing support and advocacy of the Deans of the 16 universities. There is also significant funding; the programmes are free to attend, and the ONWiE Chair is also released from some other duties and provided with a coordinator. The authors note that while the focus of the programme is on increasing gender diversity, there is a recognition that other aspects of diversity are also important; there has also been a recent move to take the one-day programme to more rural areas, to reach girls who might otherwise find it difficult to attend.

EXPERIENCES OF STUDYING ENGINEERING

The experiences of women studying engineering at undergraduate level is the focus of four of the papers. The first of these, _Less of a minority in university education in engineering? An intersectional analysis of female and male students in Canada_ by Denis and Heap, is also from Canada, and is based on an analysis of questionnaires collected from over 500 undergraduate engineers, male and female, in their second and fourth years at three universities. The analysis is informed by intersectionality (Crenshaw, 1989), defined by the authors as 'concurrently examining multiple sources of subordination that cut across each other', and considers factors in addition to gender including socio-economic background, although with little difference found between the backgrounds of male and female engineering students. The analysis is also broken down by university (named in the paper as Small, Medium and Large University) and by engineering sub-discipline, and this is perhaps the most important finding of the study. By far the majority of female respondents from all three universities clustered within sub-disciplines which had relatively high proportions of women – nearly 100% of those at Small, around 70% of those at Medium, and over 80% of those at Large University. The data is complex and detailed, and the paper warrants careful reading, perhaps as much for the dispersal of some common myths about women engineers as anything else; for instance almost all of the students, and indeed slightly more of the men (94%) than the women (91%), saw engineers as caring about society, while women felt slightly more confident about their maths and science skills than the men. Women were also more likely than men to have received an A grade in the previous year (40% compared with 26%) and less likely to have received a C (21% compared with 31%). While all students were generally committed and satisfied with their chosen career, there was also a clear difference in the experience of students across the three Universities, with Large University being seen as the most competitive and least welcoming for women.

Ro and Kim consider the experiences of women of colour as engineering students in the US in their paper _College Experiences and Learning Outcomes of Women of Color Engineering Students in the United States._ They also use Crenshaw's (1989) ideas of intersectionality, hypothesising that 'In a white, male-dominated field—in particular engineering—women of color students might be more vulnerable to tokenization and microaggression'. Their data is taken from the responses from 2,104 women students, attending 18 research-intensive US universities, to the 2016 Student Experience in the Research University (SERU) survey. The sample was then analysed within four racial groups, Asian (37%), Latina (14%), Black and other (9%, combined due to small numbers, and acknowledged as a limitation of the study design), and White (40%). The groups were compared for self-reported assessments of learning outcomes (critical thinking; research skills; communication skills; and professional skills), and for the effects on those of three types of learning experience. While all ethnicities report positive improvements for each of the three approaches, one of the main, and perhaps surprising, findings was that Asian women engineering students estimate their skills, knowledge, and learning outcomes as significantly lower than their white female counterparts. This effect was not found for Latina women and only

for critical thinking skills for Black and other women. The authors conclude that while interventions to support learning and self-assessment of skills were positive for women as a whole, these should be assessed through an intersectional lens in order to understand the differences between different ethnicities, as well as other minority characteristics.

Two further papers consider the experiences of women engineering students in the UK. Hodgkinson, Khan and Braid's case study -*Exploring Women's Experiences of Choosing and Studying Engineering and Navigation* draws on data from two focus groups with female students at the University of Plymouth. One important point that came out of the groups was the belief amongst most participants that they were treated the same as men on their degrees. However, this was belied by some of the reported verbatim quotes about their treatment by the male students, which suggested instead that they experience a bullying and gendered culture. Insights such as these show the importance and power of qualitative research in this area.

The paper *Designing Inclusive Approaches in Intensive Team-Based Engineering Learning Environments* by Peters et al. offers a positive response to this, through an account of the introduction of an inclusive approach to team-working through a 'positive psychology' assessment tool of student strengths, as part of the design of a new Integrated Engineering Programme at University College London (UCL). Unlike other approaches which attempt (as the paper points out) to 'fix the women', the introduction of the tool focuses on individual strengths, emphasising the importance of differences in teamwork. The paper reports on a number of assessments of the new programme, but these are not perhaps greatly conclusive. While all students self-assess as more confident across a range of skills by the fourth year, female students still assess themselves as significantly less confident than male students in technical skills, although as more confident in their non-technical team skills such as 'the ability to work effectively within a diverse and multidisciplinary team of people'. The paper notes that what is needed is 'cultural transformation', and that this is not likely to be 'a quick fix'.

RESEARCHING AND WORKING IN ACADEMIA

The experience of undergraduate students on engineering courses seems likely to be closely linked to that of their teachers. Several academics and practitioners have pointed out the importance of mentors, and of seeing people who look like you (see for instance the WISE campaign People Like Me (WISE, 2018), and also Mouganie and Canaan, 2019). Therefore initiatives to support women at undergraduate level are only likely to work well where there are similar initiatives supporting an inclusive culture within their university. This is the focus of two papers in this Special Issue, Gelles, Villaneuva and di Stefano in the US and Infanger and Lima in Brazil. The first of these "*Mentoring is ethical, right?": Women graduate students and faculty in science and engineering speak out* focuses on the mentoring relationship between graduate students and their advisors in science and engineering, considering instances in which either or both are female. It describes a detailed qualitative study in which mentors and mentees were invited to discuss a number of imaginary case studies of both positive and negative mentoring relationships. Through the discussion of the results, the paper provides a thoughtful and nuanced description of multiple ways in which graduate mentoring relationships could work well or less well, including some consideration of intersectional issues, such as where there may be different cultural expectations of a relationship. The paper is an important read for all of us involved in mentoring postgraduate students.

Infanger and Lima in *Maternity Leave Benefit for Researchers: a Case Study of FAPESP's Maternity Leave Policy* consider the impact of family and caring responsibilities on women engineers. They consider experiences of maternity leave in female postgraduate and postdoctoral researchers in Brazil, through a case study paper based on five researchers' experiences. This too is a thought-provoking paper, highlighting the difficulties faced by women researchers who are often in untenured positions at the start of an academic career during the same time of life as they are also starting families. While the major funding agency in Brazil now offers financial support for a four month maternity leave, all of the participants reported feeling under pressure to continue their involvement in their research project during those four months. The authors further note that, 'women who return from maternity leave are often overtaken by a stark feeling of failure', both for having not attended to their research during the maternity leave, and for feeling they are providing inadequate care for their children on return. The role of the research supervisor here is identified as critical, too, and the paper concludes that 'the crux of the issue may be the imposition of an academic productivism that weakens the ties of sympathy between peers and the academic community as a whole'.

ENGINEERING INDUSTRY

The last four papers of this Special Issue focus on the engineering industry, starting with *Pushing the Limits: The Need for a Behavioural Approach to Equality in Civil Engineering* by McCarthy et al. who offer a thought-provoking and novel assessment of reactions towards equality initiatives, set within the construction sector. Using the concepts of 'in-group' and 'out-group', the authors first consider the complex issues around the treatment of women and other minority groups within construction, and the reasons why women are more likely to leave and less likely to reach senior positions. This, as they point out, is not a problem merely of recruitment of more women; instead it is a problem of behaviour within the industry, including direct discrimination as well as both overt and covert hostility. Finding little evidence that the measures taken to address inequalities in construction actually work, being 'often episodic, rarely measured, and predominantly focused on entry-level recruitment', they discuss evidence from other fields that such measures might actually be counter-productive. The authors then test whether perceptions of general fairness within the organisation affects attitudes of employees towards gender equality approaches. Data is collected from 790 questionnaire responses from employees of three major contractors. The results show a significant correlation between perceptions of the employing organisation's fairness as a whole, and 'attitudes towards equality approaches'. This leads the authors to conclude that, before introducing equality initiatives aimed at the 'out-group', organisations should first concentrate on developing a culture of fairness within the organisation as a whole; as they point out, not addressing the latter issue before they introduce the former may well result in 'increased hostility and discrimination towards the out-group'.

Houghton's paper *Retaining and promoting a more gender-diverse workforce in an engineering consultancy through specific development training* offers a welcome missing piece of the jigsaw in providing some evidence of the positive effects of an equality intervention programme. Her case study describes the introduction of the Women's Development Programme at a UK engineering consultancy in 2011, following a commitment by the former chairman to increase the number of women. Originally attracting Government funding, but now funded internally, it has been accompanied by a number of other initiatives at the company, including a professional network for women, a 'Women's Leadership Council', additional training for line managers on unconscious bias and management of diverse teams, and the introduction of a

returner's programme, for both women and men. The data offered shows that numbers of women increased between 2012-2016 from 24% to 28%, numbers of women leaving the company reduced, and numbers of women in senior staff positions rose from 14% to 18%. While it appears therefore that the programme has itself had a positive impact, reading the case study in the light of other papers in this special issue draws a more complex conclusion. The study offers clear evidence of strong support from the very top of the organization and, through the number of related programmes and initiatives, of cultural change.

In their paper *Gender and Race Intersectional Effects in the U.S. Engineering Workforce: Who Stays? Who Leaves?,* Tao and McNeely investigate the intersectional effects of gender and race on the participation of women in the US engineering workforce, in order to provide a 'more nuanced treatment of women in engineering as a demographically varied group.' Quantitative data is taken from several years between 1993 and 2013, with a particular analytical focus each ten years, from a US statistical database SESTAT, and is divided into four racial groupings of White, Asian, African and Hispanic. The data shows that the percentages of engineering graduates who are working in engineering careers have dropped since 1993 for both men and women. In 2013 women and ethnic minority groups are also less likely to stay in engineering than male and white groups. This situation has changed particularly for women classified as White or African, who in 1993 were *more* likely to stay in engineering careers than men of the same ethnicity, but in 2013 were more likely to leave. Additional analysis is provided on why the different groups leave engineering. The answers suggest, as the authors say, the 'existence of institutional barriers' within engineering careers for women and ethnic minorities and, to a greater degree still, for minority women. The authors conclude that understanding the 'complex intersecting biases' that produce these disparities is critical in order to address them.

The final paper presented is *Where are the Women in the Engineering Labour Market? A Cross-Sectional Study* by Singh and Peers, two members of the 2017-2020 Executive Board of INWES, the International Network of Women Engineers and Scientists. They offer a unique and timely view of women's participation in engineering around the world, and of multiple actions taken to increase this participation, with the over-arching aim to offer the beginnings of 'a library of case studies of affirmative actions'. They note also that at present 'it is rare to find robust evaluation studies or even reflection on the effectiveness of such actions… [which] also have a tendency to be short-lived'. The paper first offers an overview of the situation in almost 40 countries, categorised by the authors into four broad socioeconomic-political groups, and offering a useful source of data on percentages of women working in engineering in different countries and how these have changed over recent years. This is followed by an account of a large number of diverse initiatives – from school outreach programmes to industry initiatives and the role of engineering organisations. There are lessons to be learned from these briefly described initiatives, and from the difference in approaches between the different categories of country, but the paper reiterates the need for far more detailed evidence on what works and why. As other papers in this issue have done, these authors too point out the importance of not just offering support to individual women, but also, and more importantly, of driving 'cultural change or inclusion so that women feel that their place in engineering is valued and respected'.

CONCLUSION
This Special Issue has focused on gender and intersectionality within engineering, and a number of common threads have emerged.

Firstly, it is clear that there is a problem. Several papers offer statistics on the low percentages of women who choose to take engineering degrees. Perhaps more importantly, though, Tao and McNeely show that significantly fewer women who graduate with engineering degrees remain working in engineering than men, and even fewer women from certain ethnic backgrounds. The evidence suggests that this is not to do with any mismatch between natural 'female' skills and abilities and those needed by engineers; on the contrary, Denis and Heap show that women are both more confident in their maths skills and achieve higher grades than their male counterparts. Their data also rebuffs the myth that women are more likely to see a career in engineering as for social good; on the contrary, slightly more men than women saw engineers as caring for society.

Several papers then consider the specific problems faced by women studying and working in engineering, finding clear evidence that engineering is an unwelcoming field for women. McCarthy et al. for example mention the discrimination and even hostility faced by women working in the industry, while Hodgkinson et al. document the negative attitudes that female students have to face from their male peers while they are still at university. Only one paper overtly considered the impact of having children on women engineers; while an important issue, and one in which there are evident problems particularly in academia, women in all professions are equally likely to have children at some point in their lives, and there are no reasons why this should be a barrier to a career in engineering any more than in any other field.

Other papers (Tao and McNeely, Ro and Kim, Petray et al.) considered the additional intersecting issues facing women from ethnic minorities. These authors stress the importance of understanding women as a non-homogenous population, and of assessing the experiences of women through an intersectional lens. A couple of papers also consider briefly the effects of socio-economic background; however there are no mentions of the additional negative effects of disability, or sexuality, on women's careers, which is an important research gap.

Many of the papers then discuss equality initiatives taken to address the problems, many of them aimed at encouraging more girls into engineering, and supporting women at undergraduate and entry level positions. While some evidence is offered that these have worked to an extent, it is also clear that the championship of inclusive practices is needed at the very top of the organisation – at UCL (Peters et al.), the Deans of the Ontario universities (Wells et al.) and from the CEO of the engineering firm (Houghton). What is still missing is any investigation into the importance of visible women and other minorities at these senior positions, on Boards and at the highest academic levels (Dillon and Moncaster, 2017).

While, as Singh and Peers point out, there is still a need for more research to see what works, there are a number of things that we already know. A number of papers point out that it is not the women who need to change to become engineers, but the current hostile culture that pushes women out. As McCarthy et al. imply, an organisation – and by implication an industry – in which gender equality and inclusivity is the norm is also likely to be one where everyone is treated fairly, and this cultural transformation will benefit everyone, men as well as women, and people of all characteristics. Male engineers therefore need to acknowledge their role and

responsibility in creating the culture, and actively work towards change. Sadly, the fact that so few of the paper authors are male suggests that this is not acknowledged. Finally, one paper suggests that, as a minority, women will tend to cluster in engineering areas where there are more of them. Therefore, it is essential for engineering sectors and individual organisations to ensure that they are not left behind in attracting female talent – if they stand still, and wait for change to happen, they will find that the women have gone elsewhere.

POSTSCRIPT

It was with great sadness and shock that we learned in February that Ann Denis had passed away from a cardiac arrest. Ann, with her long-term colleague and friend Ruby Heap, was just revising their paper for this special issue, and had supported us by an excellent and thorough review of another paper. Ruby adds these words:
"I am deeply saddened by the untimely death of my close and trusted friend and colleague Ann Denis. Ann was an internationally renowned sociologist whose research focus and fine scholarship were deeply rooted in her feminism and strong commitment to equity and diversity. More recently, Ann had grown very interested in intersectionality as a concept and as a research method in sociology, and she was planning to write a book on this topic. She was thus thrilled to submit our paper for the special GST issue on Gender & Intersectionality in Engineering, and she would be extremely proud to see it published". (Ruby Heap)

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