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THE NEED FOR FEMINIST APPROACHES TO SCIENCE COMMUNICATION

Catch 22 — improving visibility of women in science and engineering for both recruitment and retention

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Abstract

There is a significant under-representation of women in STEM which is damaging societal progress for democratic, utilitarian, and equity reasons. However, changing stereotypes in STEM requires a solution denied by the problem — more visible female role models. Science communicators are critical to curate the conditions to bypass this Catch 22. We propose that enhancing self-efficacy for female scientists and engineers to mentor others will generate more supportive workplaces. Similarly, enhancing self-efficacy for public engagement improves the visibility of diverse female role models for young girls. These social connections will ultimately improve the science capital of girls and other minorities in STEM.

Keywords

Professionalism, professional development and training in science communication; Public engagement with science and technology; Women in science

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Introduction

Women make up just 14% of the U.K. Science, Technology, Engineering and Mathematics (STEM) workforce [WISE campaign, 2019], an imbalance that is also reflected in international statistics [European Institute for Gender Equality, 2019]. Whilst some argue that STEM operates within a gender neutral positivist paradigm, other research indicates that STEM employment cultures are very much situated within the societal context from which they function [Thébaud and Charles, 2018]. We assert that this significant under-representation of women in STEM employment (women make up 51% of the U.K. population [Countrymeters, 2019]) is damaging societal progress for democratic, utilitarian, and equity reasons [Fogg-Rogers, 2017]. Both recruitment and retention are important — more girls need to connect with STEM professions as socially conscious, collaborative disciplines [Diekman et al., 2011], and more women need to be supported to make a difference in the workplace [Stout et al., 2011].

Gender inequality and social identification with STEM

Humans are social creatures, so the things we see others doing around us are the things we want to copy or be part of. The psychologist Albert Bandura termed this 'Social Cognitive Theory' [Bandura, 1976], where an individual's learning is not only related to personal capabilities and experiences, but also by observing others; this can be through social interactions, life experiences, or outside media influences [Bandura, 2004]. In other words, an individual might not do something just because they are good at it; they will also observe the outcome of the behaviour and how others react to it socially [Fogg-Rogers, Sardo and Boushel, 2017].

The beliefs that individuals hold about their abilities and eventual outcomes are a powerful influence on how they will behave; this is a critical aspect of Social Cognitive Theory known as perceived self-efficacy (PSE) [Bandura, 1977]. This suggests that if people believe an action will have a favourable result and they can successfully perform it, they will be more motivated to perform that action. Self-efficacy is therefore a measure of perceived ability rather than actual performance; however, people with high PSE are more likely to continue performing that action [Bandura, 2004].

This is reflected in research examining the paradox of girls' higher performance in STEM subjects but lower continuation rates into employment [Stoet and Geary, 2018]. The social value placed on STEM subjects being competitive, logical, and individualistic (which are not necessarily true) are perceived to be contradictory to the feminine gender identity traits of communality, nurturing, and sociality [Boucher et al., 2017]. This perceived incompatibility results in a conflict between STEM interests and emerging female gender identities, with research indicating this turns girls off pursuing STEM careers [Archer et al., 2013].

Girls and women therefore have lower social identification with STEM and lower self-efficacy that they will perform well in STEM. Unfortunately, this paradox continues into the workplace, with an unsupportive workplace culture being cited as the key reason why women leave engineering in one study of 2042 graduate female engineers [Singh et al., 2013]. Similarly, other research indicates that women struggle to balance feminine traits in order to succeed in male-dominated professions [Archer et al., 2012; Cheryan et al., 2011; Shapiro and Williams, 2012].

Science communication and perceptions of scientists and engineers

Science communication can present a different perspective on the culture of science and identity traits of scientists, and is therefore a critical profession for making a difference to the employment of women in STEM and a more equitable society. Public engagement with STEM has manifold ways of influencing perceptions of STEM careers; training can enhance the capacity and capability of women to take part in science communication [Trench and Miller, 2012], schools programmes can enhance both teachers' and children's capabilities for STEM [Fogg-Rogers, Lewis and Edmonds, 2016], and media or events can change ideas about the type of people who do STEM [Durant et al., 2016].

However, undertaking science communication seeking to change gender norms in STEM is a classic Catch 22 — a problematic situation for which the only solution is denied by a circumstance inherent in the problem. While projects may seek to persuade audiences that scientists and engineers come from diverse backgrounds, current statistics mean it is easier to recruit more men than women for events, and more people from white middle-class backgrounds. This can in turn reinforce perceptions of STEM, which may result in putting young women off a career where they will be in the minority [Cheryan et al., 2011].

Representations of STEM are therefore critical, and science communicators need to apply great care in the design of their programmes. Bandura [1997] identified four aspects which potentially contribute to the development of improved PSE for a topic: mastery or performance accomplishments (i.e., experiences of relevant success); vicarious or observational experiences (i.e., comparisons of capability to others, modelling and observing); verbal persuasions (i.e., positive feedback from peers and supervisors, coaching), and emotional arousal.

Indeed, viewing same-sex in-group experts (female role models) has been shown to enhance subjective identification for girls with STEM, which in turn 'inoculates' against negative stereotypes and predicts enhanced commitment to pursue STEM careers [Stout et al., 2011]. However, simply seeing women in science and engineering fields is not always sufficient, as experiences have to be positive [Buck et al., 2008]. Indeed, in order for women in STEM to be viewed as role models by girls, they need to walk a fine line between appearing to be competent in their field but neither too dominating [Hoyt and Simon, 2011] nor too 'feminine' [Betz and Sekaquaptewa, 2012].

Consequently, some studies have urged science communicators to focus on retention of women in STEM, through mentoring programmes, non-elite leadership models, and peer social support [Buck et al., 2008; Drury, Siy and Cheryan, 2011; O'Brien et al., 2017]. The implication is that as gender ratios change in STEM, workplace cultures will better suit and support women whilst enabling visible feminine identities, meaning that more girls are likely to seek to enter these professions. This does not negate the fact that societal barriers and constraints also need to be tackled to enhance workplace cultures, such as through the Athena SWAN charter mark in the U.K. [Advance HE, 2019] (see the commentary by Wilkinson in this issue). However, social identity theory [Tajfel, 1974] does indicate that in order to change stereotypes, it is best to present many different types of women who subtly alter from the 'norm' in order to expand normative social roles [Koenig and Eagly, 2014].

'You can't be it if you can't see it'

We therefore argue that science communication has a vital role to play in socially engineering representations of scientists and engineers, in order to change perceptions and stereotypes in STEM. This is not without acknowledged criticism; in previous work by the authors, purposively recruiting women to achieve a 50/50 gender ratio in the engineering communication project Robots vs Animals was a practice disliked by some male participants as they perceived it as positive discrimination [Fogg-Rogers, Sardo and Boushel, 2017]. However, we argue that unless women are supported in STEM recruitment and retention, then the gender imbalance in STEM careers will never change. As a case study for this commentary, we describe outcomes from the 'Women Like Me' project, which aimed to apply lessons from the social psychology literature to support women in engineering.

Women like me

In total, 52 professional female engineers working in industry or research in the West of England region were trained in public engagement and outreach ('junior' engineers with $\leq$5 years' experience, N=26) and mentoring ('senior' engineers with 5–32 years' experience, N=26). Junior engineers carried out a target of three education outreach activities each, with senior engineers providing at least two mentoring sessions to the junior engineer with whom they were paired through the scheme.

Schools with higher than average numbers of students from lower socioeconomic backgrounds were specifically targeted for the outreach and engagement activities. Boys were also included in outreach activities, as this provides an opportunity to view women performing public engagement and thereby challenges social norms about what engineers look like; research indicates that opposite-gender role models do not have negative impacts on boys' career aspirations [Lockwood, 2006]. The outreach activities resulted in over 10,240 children participating in public engagement with women engineers.

Feedback from schools indicated that girls especially benefitted from seeing women in engineering roles, particularly when ethnicities were similar [Fogg-Rogers and Hobbs, 2019]. Teachers, for example, reported that seeing female engineers from diverse backgrounds encouraged girls to consider that more stereotypically 'masculine' subjects might be open to them, allowed students from BAME backgrounds to relate to BAME engineers through shared identities, and raised aspirations in lower-attaining students.

All 52 engineers completed questionnaires at the start of the project, and 31 completed questionnaires at the end. For the junior engineers surveyed at the end of the project, the main benefits reported were improved communication skills and the opportunity to network and establish new contacts with other women engineers. Their PSE for education outreach was assessed using the Education Outreach Self-Efficacy Scale [Fogg-Rogers and Moss, 2019] at the beginning and end of the project. A Wilcoxon Signed Ranks test showed that the mean score for the junior engineers improved substantially (and statistically significantly) from 6.80 to 8.41 (score out of 10 — Z=-3.05, p=0.002), indicating that the engineers were more confident to undertake education outreach after completing the project (Figure 1). Interestingly, the scores for the senior engineers (who did not receive education outreach training) did not show a statistically significant increase (rising slightly from 6.53 to 6.99, but not significantly Z=-1.07, p=.285). Indeed, the junior engineers subjectively reported that they felt more equipped to take part in public engagement, with 54% of junior engineers feeling fairly well equipped before the project, increasing to 68% after the project, with 38% indicating they were very well equipped.

Each mentoring pair of junior and senior engineers received training in mentoring and then met at least twice throughout the project. While the junior engineers initially reported that they wanted training and development information, the most popular topics discussed were actually career progression and work/life balance, indicating how valuable it is to generate women's support networks. Qualitative feedback indicated that the junior engineers benefitted from meeting other engineers in the same position — as a woman in engineering and also learning about public engagement.

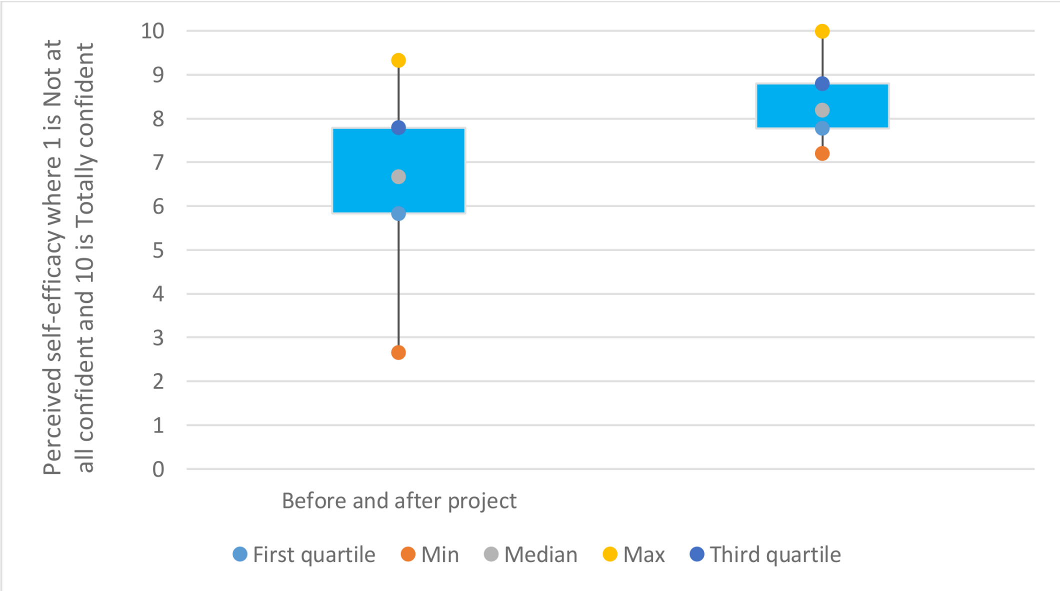

Figure 1. Engineering Outreach Self-Efficacy measured before and after Women Like Me for junior engineers.

> *It was great having opportunities to discuss career paths, personal experiences, advice with someone who's had five years or so further along and they're in a similar career. I felt like I could understand a bit further where my own career might go and gain a bit more self confidence in my own uncertainties and experience levels in this point in time. [Junior Engineer]*
>
> *Having a mentor felt like having a safety net, having someone impartial and able to view things from the outside put things into perspective and allowed me to open up about issues and equally successes. [Junior Engineer]*

Structured support to change perceptions of STEM

Science communication has a vital role to play in representing STEM workers and industries, to ensure that entrenched traditional stereotypes of science and engineering do not continue to influence future generations of young people. More diverse workforces have been shown to produce more creative and financially profitable outcomes [Roberge and van Dick, 2010], and as such, more diversity in STEM will ultimately enable progress towards a more equitable society.

Science communicators are critical to curate these conditions to bypass Catch 22. By enhancing the capacity and self-efficacy for mid-career female scientists and engineers to mentor others, it is hoped they will generate a more supportive workplace for junior female staff. This means that women are more likely to be retained in STEM industries through experiencing in-group same-sex role models, and positive vicarious experiences with peers. Consequently, there are then more diverse female role models to represent women in STEM, which we hope will ultimately change perceptions of STEM careers.

Providing training for women scientists and engineers in education outreach, along with supported opportunities for public engagement, is essential to improve self-efficacy for education outreach. Enhancing the capacity and self-efficacy for female junior scientists and engineers to undertake more public engagement means they are more visible to act as positive role models for young girls. These social connections will in turn boost the science capital of girls and other minorities in STEM, and enhance their ability to continue in these rewarding careers.

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