



A Systematic Literature Review of the Impact of Undergraduate Work Experiences on Women in Engineering

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Abstract

Numerous studies have examined the reasons that students leave engineering pathways, identifying a strong sense of self-efficacy as a key indicator of students' retention and persistence. Research has hypothesized that mastery experiences, such as cooperative education, typically develop self-efficacy, but the impacts may vary between genders (Mamaril & Royal, 2008). The disproportionate representation of women at all points along the engineering pathway offers a strong motivation to study the full extent of how cooperative education and internship experiences differ between genders and how those differences manifest themselves in student retention and persistence.

To better understand these differences, a systematic literature review was used to identify and examine all relevant existing knowledge of the effects of undergraduate work experiences on key factors in student retention. This method allows for a holistic perspective by sourcing information from multiple sources and primary studies. Inclusion criteria are defined as follows: (1) examines participants of an undergraduate engineering program who are employed full-time before obtaining their degree; (2) presents empirical research or evaluates results of affective student outcomes; (3) disaggregates data by gender; (4) published as a report, article, conference paper, or dissertation in English since 1990. The search yielded 13 results.

Examining these results provides insight into students' experiences. Most studies examined some measure of interest or efficacy, noting benefits from working as a student. The quantitative studies measured a range of different outcomes, but almost never found statistically significant relationships by gender. However, qualitative studies revealed that the type of and perceived importance of interpersonal relationships in the workplace are drastically different between genders. Most students valued professional role models, but women perceived greater significance in these mentors. Women also consistently reported mistreatment and blocked access in the workplace; these experiences contributed to feelings of self-doubt and often caused women to question their future in engineering.

Background

The National Science Board's annual report on science and engineering indicates that 20.1% of bachelor's degrees in engineering are earned by women, who go on to hold only 14.5% of industry engineering positions (National Science Board, 2018). This increase in the already disproportionate representation throughout engineering pathways offers a strong motivation to study women's experiences and factors that influence their career decisions. Several studies have examined the reasons that students leave engineering and have identified a strong sense of self-efficacy as a key indicator of both retention and persistence. While self-efficacy can be developed in variety of ways, research has shown that mastery experiences can be very influential developers of self-efficacy in both men and women (Mamaril & Royal, 2008).

Cooperative education programs and internships, two such mastery experiences, are becoming increasingly more common in undergraduate engineering and influential in securing future employment. In cooperative education programs, students rotate between semesters of full-time

employment and coursework, sometimes on a university-mandated schedule. Internships tend to occur only during summer months and participation is typically voluntary. As students participate in co-ops and internships more frequently, it is important to understand how these experiences impact women during their undergraduate career. A systematic literature review is needed to identify and examine the following:

1. How are the outcomes of undergraduate work experiences measured?
2. What outcomes, if any, see gendered differences?
3. How do those differences manifest themselves in students' career decisions?

Relevant results have been published across a wide range of sources, but have not been synthesized to create a comprehensive report on this common feature of undergraduate engineering education.

Methodology

Systematic reviews can provide comprehensive summaries of previously conducted research, assessing both the general understanding of and the gaps within the literature of focus. By synthesizing the existing body of knowledge, these reviews provide easier access to the literature and foundations for future work. Systematic reviews are guided by the following procedure: (1) identification of research questions and bounds of the focus area; (2) a systematic search and filtration of existing literature; (3) assessment and coding of selected publications; (4) synthesis and dissemination of results (Borrego, Foster & Froyd, 2014).

A comprehensive collection of relevant publications was compiled by identifying appropriate search terms, databases and inclusion criteria. Ebscohost was to search the following databases: Academic Search Complete, Business Source Complete, Educational Administration Abstracts, Education Source, ERIC, Gender Studies Database, PsycINFO, Science & Technology Collection, and SocINDEX with full text. Additional searches were conducted within ProQuest, Engineering Village, Web of Science and World Cat.

The search terms used limited the results to peer-reviewed publications which contain terms and synonyms for gender, engineering, undergraduate, and work experience. An initial search narrowed the results to exclusively cooperative education programs, but due to the small number of relevant results, the search was expanded to include engineering internships, another common formal work experience that undergraduate students may partake in before graduation. The search results from each database were examined using the following inclusion criteria: (1) examines participants of an undergraduate engineering program who are employed full-time before obtaining their degree; (2) presents empirical research or evaluates results of student outcomes; (3) disaggregates data by gender; (4) published as a report, article, conference paper, or dissertation in English since 1990.

Results

The search within Ebscohost identified 216 results. Once 84 duplicates were removed, the titles and abstracts of the remaining publications were screened using the inclusion criteria. 79 results were removed. The full-text of the 53 remaining results were then evaluated, leaving 14 qualifying studies. This process was repeated for each database searched, while also removing results that were already collected from the preceding databases, so that only unique studies

remained. Searches were conducted within ProQuest, where 13 results were narrowed to 3, within Engineering Village, where 98 results were narrowed to 8, within Web of Science, where 58 results were narrowed to 3, and within World Cat, where 153 results were narrowed to 2. From the five databases searched, a total of 30 unique, qualifying studies were then evaluated with respect to the purposes of this review. A second reviewer jointly screened these qualifying studies and helped eliminate 17 articles, leaving a total of 13 qualifying studies.

Sources were evenly distributed between the databases searched and include 6 American Society for Engineering Education conference papers, 4 journal articles, 2 dissertations, and 1 poster from an NSF Human Resources Division Annual Meeting. The journal articles were published in the *Journal of Research in Science Teaching*, *Journal of Engineering Education*, and *Work and Occupations*. The 13 qualifying studies include 1 mixed-method, 6 qualitative and 6 quantitative studies. The sample sizes ranged from 4 to 15,771. All the sources included were peer-reviewed and framed as research studies, rather than as practitioner papers. Additionally, the quality of each of these studies was systematically assessed. The full texts of the 13 remaining qualifying studies were then examined and coded to reveal themes within the existing body of knowledge.

Discussion

Although the total number of publications examined was quite small, clear trends existed in the data collected. The majority of articles measured students' confidence or some form of self-efficacy in the classroom or the workplace. The quantitative studies measured a variety of outcomes, but almost never found statistically significant relationships in these outcomes by gender. Interpersonal relationships in the workplace, however, were drastically different between gender groups. Women reported positive outcomes from interacting with professional role models that were both more frequent and more significant to their experiences than their male peers did. However, women also experienced a wide range of mistreatment while working.

Non-Gendered Outcomes

Self-efficacy, in its various forms, is a commonly used indicator of the benefits of co-ops and internships. Many studies spoke directly or indirectly of work self-efficacy, a measurement of students' confidence in their ability to perform requirements of the workplace (Raelin et al., 2007). Work self-efficacy, while slightly dependent on the level of responsibility given to a student, increases with every employment and has been shown as a strong predictor of desire to graduate and retention rates in engineering (Raelin et al., 2014). Pink et al. (2017) examined the impact of work experiences on question-asking self-efficacy, social outcome expectations, and career outcome expectations and found positive correlations across all measures.

Ramirez, Main & Ohland (2015) found work experiences increased cumulative GPA, likelihood of graduating in engineering and time to graduation. Schuurman, Pangborn & McClintic (2008) found students with work experience were more likely to receive a job offer and started at a higher salary than their peers. Other studies examined interest in engineering careers and coursework, skills learned during employment and value placed on the experience (Creamer, Burger & Meszaros, 2007; Pierrakos, Borrego & Lo, 2008; Raelin et al. 2014). Overwhelmingly,

these publications show that students with work experience benefit compared to their peers across these measures, and report no significant differences by gender.

Working also allows students to see the applications of the theory they have been exposed to in the classroom and puts their knowledge into real-world contexts (Case & Jawitz, 2004). While some students report that the disconnect between school and work content decreases their academic drive or perceived value of their coursework, most report that applying their knowledge in a working environment increases both their interest in engineering career paths and their motivation to graduate (Gunderson et al., 2016; Hyde, 1997; Kuntz, 2009). These feelings showed no significant divides between genders. From this information, it was determined that these commonly cited measures are not sufficient to explore the major discrepancies between men and women's experiences.

Mentorship and Professional Role Models

Undergraduate work experiences are most dramatically gendered within the interpersonal aspects of the workforce. Several studies report correlations between exposure to and work done with role models in the workplace and increased enjoyment of the experience, responsibility given during employment, and self-confidence (Case & Jawitz, 2004; Gunderson et al., 2016; Kuntz, 2009; Samuelson & Litzler, 2013). Both men and women report positive experiences with mentors of same and opposite genders, but the impact of professional women is more significant for women undergraduates (Gunderson et al., 2016). These students felt that seeing women at work helped offset self-doubts they attributed to being in a heavily male-dominated industry. These professional women allowed the undergraduates to see how they could fit within engineering culture and increased their interest in engineering careers (Samuelson & Litzler, 2013). Women have been shown to both use and benefit more from mentorships and often cite a professional mentor as a crucial part of their positive experience during an internship or co-op rotation.

Mistreatment in the Workplace

The interpersonal working relationships reported by women are not uniformly positive. Despite the importance mentors played for many women, students often felt marginalized by their gender at work and an overwhelming majority of women interviewed about their experiences during co-ops or internships reported encountering a hostile work environment (Case & Jawitz, 2004; Gunderson et al., 2016; Kuntz, 2009; Seron et al., 2016). Undergraduate women recalled a wide range of instances of mistreatment and harassment, including cat-calls and pornographic images in factory environments, inappropriate comments about their wardrobe, crude jokes, unsolicited flirtations and evidence of virtual stalking from colleagues, and being asked out to dinner by a member of upper management.

Beyond blatant sexual harassment, women also reported experiencing many professional disadvantages (Case & Jawitz, 2004; Kuntz, 2009; Seron et al., 2016). Examples include being given office work instead of engineering work, having their comments and suggestions ignored in meetings when their male peers' input was acted upon, being sent to run favors for male members of their team because their coworkers felt the action would be completed quicker for a

woman, and having access to networking opportunities blocked or limited by their gender. Their male peers often reported hearing inappropriate comments and gendered criticism when no women were around, and noticed a higher level of responsibility entrusted to male students than to female students. These hostile experiences often caused female students to question if they would ever be taken seriously in the workforce or valued as an engineer. When reflecting on their working experiences, these women identified moments of extreme self-doubt that stand in sharp contrast to the growing confidence and career satisfaction their male peers recounted (Case & Jawitz, 2004; Seron et al., 2016).

It is important to note that while some accounts of this mistreatment in the workplace occurred in studies during the early 2000s, two were published in 2016, indicating this culture is consistent throughout time and still relevant to women in engineering today (Gunderson et al., 2016; Seron et al., 2016).

While witnessing and experiencing mistreatment, most undergraduate students believed it was best not to call attention to these interactions and often explained away the situation with sentiments like “men will be men.” Some female students seemed to accept that demeaning comments and experiences would always be a part of their career in engineering because the field remains male-dominated (Seron et al., 2016). Others were convinced that the workplace environment would change over time as the older employees retired and more women entered the workforce (Case & Jawitz, 2004). Regardless of their stance, the isolating environment they encountered often caused them to question their interest in engineering as a career pathway. However, the parity that remains across quantitative markers strongly indicates that nevertheless, these women persisted.

Conclusions

The positive impact that undergraduate work experiences have on engineering students’ work-
efficacy, cumulative GPAs, retention rates, etc. is well documented in the literature. However, these measures typically show no significant relationship with gender. Hypothesizing that men and women’s early experiences in the workforce would differ from one another, this study sought to understand these variations by synthesizing results from existing literature. While the total number of qualifying studies for this systematic review was small, the synthesis still illuminated gaps in the current body of knowledge. From this examination, it is clear that the commonly used measures cannot account for disparities in interpersonal aspects of co-ops and internships.

While interning or co-oping, women often experience blocked access to professional opportunities that can be extremely influential in developing self-efficacy. They are confronted with gender stereotypes, harassment and marginalization in the workplace that have implications for what their career would look like after graduation. These experiences often plant seeds of self-doubt about both personal ability and fit within the industry, causing many women to contemplate leaving the engineering pathway. While this mistreatment did not show any impact on retention, these and workplace experiences after graduation may compound and contribute to the low representation of women in the engineering workforce.

Neither women nor their male peers who witness mistreatment feel empowered to report these gendered incidents; accounts of sexism were only found through interviews and focus groups aiming to learn about students' work experiences. Because the sample size of these qualitative studies is quite small, future work should aim to expand samples and research methods in order to argue that the issue is truly widespread. However, the consistency of these account across sources within this review strongly imply that sexism is still a prevalent part of women's working experiences in engineering today.

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