Underrepresentation of Women in Science, Technology, Engineering, and Mathematics Professions

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[Second Place]

Historically women have been pushed to pursue careers that are deemed more nurturing, delicate, and feminine such as nurses, teachers, and housekeepers. The patriarchal stereotypes that women are the weaker sex and are not knowledgeable in science-orientated careers may explain the gender gap of males and females in science, technology, engineering, and mathematics (STEM) professions. In the late 20th and early 21st centuries, there has been an effort to encourage women from an early age to engage with STEM courses in order to decrease the underrepresentation of women in STEM. However, from the early stages of adolescent development through the stages of university and professional careers, there remains a gender and wage gap between men and women who pursue STEM related occupations. The obstacles women face when pursuing these professions contribute to why women are a minority in the STEM field. As early as elementary school, women are under the preconceived notion that their male counterparts outperform them in science and mathematics leading to gender and wage inequality within STEM professions.

A study conducted by Wieselmann, Roehrig, and Kim, used Social Cognitive Career Theory to examine the correlation between self-efficacy and the preliminary career choice between elementary school girls and boys. Wieselmann et al. sought to provide evidence to determine if a female student's self-efficacy was driven by influence from male peers depending on the type of learning environment. In a previous study that the authors cite "over 6,000 students showed that girls' STEM career interests declined throughout high school while boys' interests remained more constant; by the end of high school, only 12.7% of girls indicated an interest in pursuing STEM-related careers, compared to 39.7% of boys" (Wieselmann et al). According to the authors, there is a strong correlation between how females have been socialized to not "jeopardize their identities as good students" (Wieselmann et al. 234) and the style of learning that they are subject to. The current curriculum supports the practice of standardized tests in a classroom setting, the instructor will prepare the students for the standardized tests instead of providing an environment where teamwork and communication are prioritized. Wieselmann et al. hypothesized that if education systems wanted to continue to encourage female's interest in STEM, unique out-of-school learning experiences might help. Until this study was conducted, there was very little research on how out-of-school STEM experiences impact students with all varying degrees of interest in STEM, especially female students (Wieselmann et al. 236). Therefore, the authors designed their study to include female students with varying degrees of interest in STEM.

Participants in the study were female students aged 10-11, and "each participant was visiting Designs in STEM with her classroom teacher and grade-level peers, including both

boys and girls" (Wieselmann et al. 236). Designs in STEM is a nonprofit program that designs STEM-orientated activities for youth.

The study used interviews as the primary source of data along with observations noted by researchers of interactions between students during their time at Designs in STEM. When conducting preliminary interviews with female students aged 10-11 who were asked about their feelings on mathematics and sciences, there was a large negative position taken by the students. When asked about science alone, there was more of a positive reaction. Post-interviews were conducted after the students' time at Designs at STEM and the female students "went on to explain that the actual mathematics content and skills...were similar at school and Designs in STEM, but the contextualized nature of completing the calculations at Designs in STEM made it more fun and useful" (Wieselmann et al. 238). The researchers discovered that the female students who did not show interest in STEM before, positively responded when discussing future STEM careers. The nature of the program Designs in STEM focused on having students engage in activities that used science and mathematics in a real-world context thus allowing female students to stray from their usual learning environment. When the female students were asked to describe their male peer's behavior, there was an agreement that their male peers seemed distracted and chatty. As researchers discovered, the female students equated intelligence synonymously with speed and tracking. Their male peers were able to complete mathematical problems quicker than the female students and thus excelled in more advanced and gifted classes (Wieselmann et al. 239). There seemed to be a negative impact on female students' self-efficacy when observing their male peers who were deemed as distractible still gain achievements in science and mathematics. Therefore, driving female students away from STEM subjects because of the socialization that female students receive, that they must be good students. Cited in the article by Wieselmann et al. previous research demonstrated that "girls often display prosocial academic behaviors to demonstrate their responsibility, but these behaviors are not necessarily linked to deeper cognitive engagement with content" (239). According to the authors, these behaviors exhibited by female students are caused by the design of the classroom environment where being fast at mathematics means success in STEM. The design of the classroom may push female students away from STEM at an early age. The authors note that there are implications to the study where educators must consider mathematics as the gateway to other STEM courses. The authors agree that there must be thought into how mathematics is taught in school systems to invoke persistence in female students through engaging activities.

Research conducted by Wieselmann et al. focused on the early stages of adolescence and the stereotypes that already exist around STEM subjects along with its impact on female students. Other researchers have conducted studies on how those stereotypes can contribute to poor academic performance in later academic years. In the article, Stereotype Threat Impairs Ability Building: Effects on Test Preparation Among Women in Science and Technology, the authors Appel, Kronberger, and Aronson define the stereotype threat as "a state of psychological discomfort that, if sufficiently acute, can impair performance" (904). Appel et al. give an example of stereotype threat that "may occur when a woman who is aware that women are considered inferior to men at math is confronted with a mathematics test" (Appel et al. 904). The authors examine how this stereotype threat can lead to poor test preparation which include note taking capabilities, retention of information within the notes and the memorization of information after. The authors conducted four different studies that built off one another.

In the first study, the authors investigated whether there was general knowledge about

the stereotypes about men and women within STEM related subjects. The participants within the study were men and women aged 16 to 75 who answered a series of questions through an online questionnaire pertaining to the beliefs of men and women in STEM. It was hypothesized that "our female participants believe that others view women as less able than men to learn in STEM domains" (Appel et al. 905). The study revealed that participants agreed that "although women are expected to be good learners in general, they are expected to be less proficient than men in learning the traditionally male fields of the natural sciences and engineering" (Appel et al. 906).

Having confirmed the hypothesis and confirmed that both sexes were aware of stereotype threats, the authors designed the second study to determine whether this stereotype threat resulted in inadequate note taking. It was hypothesized that "students under stereotype threat take lower-quality notes" (Appel et al. 906). Forty females, ages 19 to 43, were randomly assigned one of two readings. One reading "highlighted gender differences; however, it did not explicitly mention achievement-related characteristics" (Appel et al. 906). The second stated that there were no differences in STEM abilities between genders. Participants then took notes on computers within a computer lab, about the readings that were then examined by two instructional psychologists, who rated the quality. The data demonstrated that indeed, those who read the first reading took lesser quality notes than those who read the second (Appel et al. 907).

The third study was designed similarly to the second, except the participants received readings specifically about the stereotype threat within the STEM field. It was hypothesized that under the stereotype threat, participants would take lesser quality notes. The participants were randomly assigned either the stereotype threat reading or the control reading and "were asked to take notes that would be most helpful for themselves as well as for fellow students when preparing for an exam" (Appel et al. 908). Results indicated that the author's hypothesis was correct; subjects that read about stereotype threats took poor notes.

The fourth study investigated the ability of participants to choose relevant, high-quality notes under stereotype threats. Participants were females aged 18 to 33 and were randomly assigned to three different readings. The first reading implemented the stereotype threat, the second remained the control, and the third "emphasized that, although men outnumber women in most STEM study programs, standardized tests indicate that men have worse learning abilities in math and science" (Appel et al. 909). Participants had to sift through notes and encyclopedia articles about each respective reading, except some of the articles contained wrong information, and some of the notes had been altered. The results indicated that "when the negative group stereotype was activated, women failed to distinguish between low-quality and high-quality information" (Appel et al. 910).

With these four studies, the authors provide more than enough evidence that the stereotype threat exists and impacts test preparedness. In a cited study by Appel et al. it was discovered that when under the stereotype threat, women would choose simple tasks over complex ones. Appel et al. cites "when girls had the choice between an easier, an appropriate, or challenging task, girls who thought the tasks prompted mathematical abilities more often chose the easier problems to solve than did girls in the control group" (911). When the stereotype threat is present that males perform better than females in STEM fields, in order to avoid failure or mistakes, females will avoid STEM domains. There are consequences with stereotype threats among women within the school who want to progress within the STEM fields.

With the research into the existence of stereotype threats, it provides insight on chal-

lenges women may face as they advance in their STEM careers. Progressing through university can be difficult due to discrimination women face in STEM paths, but those who graduate university may not only face just discrimination. An article published in the Australian Journal of Labour Economics, written by Dockery and Sherry, discusses how after graduating with STEM qualifications, women are subjected to limited wages, salary advances, promotions and job opportunities. Dockery and Sherry cite a report by the Office of the Chief Scientist in Australia in 2016, that 2.3 million people received a Bachelor's degree or higher in STEM qualifications that include "fields of Natural and Physical Sciences (NPS), Information Technology (IT) or Engineering and Related Technologies (ERT)" (127). Out of those 2.3 million people with STEM qualifications, 84% were male (Dockery and Sherry, 127). This indicates a significant gender gap within the STEM labor market, but the authors note that there have been funds granted for the sole purpose of supporting projects and STEM courses for women. Yet the data demonstrate that STEM careers are still mostly occupied by men with little change to positively impact women's careers.

The authors used data gathered from the Australian Bureau of Statistics Census data and the Household, Income, and Labor Dynamics in Australia Survey (HILDA) to conduct their study. The authors hypothesized that using the data from both sources, there would be evidence to support that despite the movement to improve the underrepresentation of women in STEM careers that there is still lower unemployment rates, lower wages, and bias towards women who have families (Dockery and Sherry, 130).

The authors first compare the Australian Bureau of Statistics Census data from 2006 to 2016 in order to recognize trends between women with STEM qualifications, women with non-STEM qualifications, men with STEM qualifications, and men with non-STEM qualifications within the workforce. Upon examination, the authors concluded that "Women with STEM qualifications had a marginally lower labor force participation rate than other tertiary qualified women in both 2006 and 2016" (Dockery and Sherry, 131). This provides evidence that women with STEM qualifications face a harsher hiring process than women with non-STEM qualifications. When examining the male participation rate, men with STEM qualifications and men with non-STEM qualifications remained consistent until a slight increase for men with STEM qualifications. The authors compared trends and concluded that women with STEM qualifications are the lowest participants within the labor force.

When comparing the unemployment rate from 2006 to 2016 of women and men with STEM qualifications, a gap emerged where women with STEM qualifications had a higher unemployment rate than their male counterparts (Dockery and Sherry, 131). The authors then focused on women and men with STEM qualifications in IT and engineering related fields and found that the female unemployment rate in IT "was 2.3 percentage points above the male rate of 3.9 percent; and for those with qualifications in an engineering and related field, the female unemployment was 2.9 percentage points above the male rate of 3.2 percent" (Dockery and Sherry, 131). The authors stated that from 2006 to 2016, there was a significant gap between the genders.

The authors then examined data from HILDA, which surveys participants over the age of 15, annually. These participants are individuals in selective households and respond to survey questions about their professional history, wealth, family orientation, education and others (Dockery and Sherry, 133). The authors narrowed down the HILDA respondents only to those who attained a Bachelor's degree or higher and examined unemployment, wages, and participation rates in the workforce.

The authors concluded that "Wages of women with STEM qualifications were 79.1 percent of those of their male counterparts, but among those with non-STEM qualifications, women's hourly wages are 86.3 percent of male wages'' (Dockery and Sherry, 136). The author's research demonstrates that not only do women with STEM qualifications earn less than their male peers but less than women who are in the workforce with non-STEM qualifications.

Participation, unemployment, and the pay gap all contribute to how underrepresented women are in STEM careers after university. Those few women who make it into a STEM profession and display mastery of the subject matter are still struggling to participate in professional settings. During the conferences, the International Congress for Conservation Biology and the European Congress for Conservation Biology, twenty sessions were observed by authors Hinsley, Sutherland and Johnston. Hinsley et al. acknowledge that there are "Gender imbalances" within STEM careers and especially "with women particularly underrepresented at senior levels" (1). The authors attended these conferences to conduct a study about the differences between male and female participation in "speaking up" and asking questions during presentations (Hinsley et al. 2). In 81 previous studies Hinsley et al. cites "gender-based differences in classroom interactions found that boys participated significantly more than girls" (2). The authors confirm that these previous studies' findings remain true in more recent studies and speculate that they may be linked to declines in female self-esteem.

Within the scientific community, participation, appearance, and status affects individual and community behavior, which can reflect on reputation which "may then lead to invitations such as opportunities to collaborate, give talks, apply for positions etc and so influence the actual contribution made" (Hinsley et al. 3). Hinsley et al. hypothesized "that women are less likely to participate in the question sessions at a large scientific conference, due to behavioral differences linked to external factors" (Hinsley et al. 3). During the time of the conferences, at four randomly selected intervals, 10 "synchronized parallel sessions" were observed by a team (Hinsley et al. 5). During the sessions, observers made note of gender and age of the audience members and recorded questions asked in either the over 50 years old category or under 50 years old. After data was collected over 31 different seminars, the authors had collected 270 questions 152 of them from men and 118 from women (Hinsley et al. 5). Hinsley et al. reported that "on average there were 0.08 questions asked by each female audience member and 0.14 questions asked by each male audience member" (Hinsley et a. 7). Which translates to men asking 64% of questions, which encompasses all ages. Even when the over 50 and under 50 age groups were separated, the authors found that "young men would ask 66% of the questions asked by younger researchers and that therefore younger male researchers ask 1.8 questions...for every question asked by younger female researchers..." (Hinsley et al. 7).

Hinsley et al. speculate that it might be a possibility that the difference in questions may reflect upon a female scientist's confidence and "who are likely to have faced academic and professional barriers based on their gender that men have not" (2). Throughout the progression of a female scientist's career, she has faced stereotype threat, struggled to find employment, and other discrimination which brings down self-esteem leading to less participation within large gatherings.

Throughout females lives, females are under the preconceived notion that their male counterparts outperform them in science and mathematics subjects in school leading to gender and wage inequality within STEM professions. From as early as elementary school, young females are immersed in an educational environment where the curriculum is focused on preparing students for standardized tests in-

stead of building values of communication and teamwork. As researched by Wieselmann et al., creating unique out of school STEM experiences to encourage female participation within STEM subjects, benefits their confidence and provides curiosity to pursue STEM subjects in school. As females progress through their academic careers, they face a stereotype threat that further separates their engagement in STEM subjects within school. Research conducted by Appel et al. reveals evidence that there is a stereotype threat that impacts test preparedness and test performance for females. This stereotype threat results in lower test scores for females on STEM subject tests which results in females avoiding STEM domains. Females who graduate university with STEM degrees also face blockages when finding employment opportunities such as limited wages, salary advances, and promotions, as researched by Dockery and Sherry. Dockery and Sherry provide evidence that females with STEM qualifications face a harsher hiring process opposed to males with STEM qualifications, males without STEM qualifications, and females without STEM qualifications. This leads to lower employment and underrepresentation of women in STEM careers after university. The few females who make it into a STEM profession and display mastery of their subject matter still face discrimination in professional settings. Research conducted by Hinsley et al. provides evidence that during scientific conferences, females are less likely to ask questions than males due to a lower confidence level. A lower confidence level may be contributed to discrimination females have faced throughout the progression of their career. Females face discrimination from an early age and throughout their education which leads to the underrepresentation of women in STEM fields. Significant change should be enacted on how females are educated throughout their lifetime in order to build confidence and excitement for STEM subjects to create engaging and equal opportunities for females to pursue STEM fields.

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