QUEST Research Paper

Essential Question: Why is there a lack of women in the fields of computer science and engineering and how can legislation and nonprofits increase these numbers?

Though women constitute 56% of university students in the United States, they only hold 13–33% of bachelor's and master's degrees in computer science and engineering (Dasgupta and Dennehy). Women, though aptly represented in Science, Technology, Engineering, and Mathematics (STEM) fields as a whole, are greatly underrepresented within STEM in the fields of computer science and engineering. This is displayed in not only the workforce, but in education as well. According to Assembly Bill 1054 from the California State Legislature, 60% of all high schools in California do not offer a single computer science course. Only 5% of students are enrolled in computer science courses in California. Of those students, 30% are girls (California State, AB 1054). California is regarded as one of the most technologically advanced states in the United States of America as it is home to Silicon Valley. One could reasonably assume that most, if not all, of the students in this state would be subject to a computer science education; however, this is not the case. There is a lack of available computer science education courses in high schools, and where courses are offered, few students are girls, leading to fewer people pursuing computer science and engineering degrees in college. The Pew Research Center, a nonpartisan, American think-tank, states that though 53% of college STEM degrees are earned by women, only 22% and 19% of engineering and computer science degrees are earned by women (Fry et al.). The discrepancy regarding what degrees women pursue within STEM in college inevitably leads to a discrepancy in the number of women who work in these fields. The National Science Foundation, an independent agency of the United States federal government supporting research in the fields of science and engineering, reports that women make up 26% of all computer and mathematical scientists and 16% of all engineers ("The STEM Labor Force").

Eitan Frachtenberg, a visiting associate professor of Computer Science at Reed College, and Rhody Kaner, a student of Computer Science at Reed College, states that only around 15% to 30% of computer science researchers are women. Of those researchers who are women, only around 10% are published authors (Frachtenberg and Kaner). Publishing research is what introduces one's findings to the scientific community and allows for further research to be pursued; without publishing research, researchers' work goes unnoticed and uncredited. These challenges extend beyond lack of women in the workforce, and there are several factors that contribute to the lack of women in the fields of computer science and engineering.

There are a multitude of factors that contribute to the lack of women in the fields of computer science and engineering. According to an article published in the *Journal of Advanced Academics*, a peer-reviewed academic journal, and an article published in the *Journal of STEM Education: Innovations & Research*, a peer-reviewed, STEM-focused publication, these include, but are not limited to: environmental factors, stereotypes, a lack of female computer science teachers and classmates, lower self-efficacy in engineering, and a lack of access to computing education and resources (Bahar et al.; Pinnell and Schilling). Environmental factors heavily contribute to the lack of women in these fields. For example, parental perceptions have led to fewer women pursuing computer science and engineering because they do not place as much value on their daughters' abilities in STEM fields and overvalue their sons' abilities in these fields. This results in girls having less parental encouragement to pursue careers in these fields, lowering their interest in computing and engineering (Bahar et al.). Additionally, there are an abundance of stereotypes in the fields of computer science and engineering, as well as regarding STEM fields as a whole. A majority of these stereotypes pertain to computer science, engineering, and mathematics in general being masculine, and therefore, not suitable for women

to pursue (Pinnell and Schilling). Because of these factors, there are fewer women who not only pursue computer science or engineering but also who teach in these subjects. Girls not seeing many teachers or peers that are similar to them results in women who are attempting to pursue these fields to feel out of place, which damages their self-efficacy and leads to fewer women pursuing careers in these fields. This vicious cycle, perpetuated by stereotypes and environmental conditions, limits the number of women in computer science and engineering. Another major factor in the lack of women in these fields is a lack of access to computing education and computing resources (Bahar et al.). Without these, women would not be able to expand their knowledge in computer science and engineering and pursue careers in these fields. Addressing these barriers is crucial to increasing the number of women in these fields.

The lack of women in the fields of computer science and engineering perpetuates a cycle of fewer women in these fields. Dr. Kadir Bahar, an assistant professor in the Department of Educational Psychology at the University of Georgia, Dr. Erdogan Kaya, an assistant professor at George Mason University with a Ph.D. in Curriculum and Instruction, and Xiaolu Zhang, a Graduate Assistant at George Mason University, state that women make up over half of the nation's workforce and are heavily represented in social science and education careers; however, they only comprise around 30% of STEM occupations. Women only occupy one out of four CS jobs (Bahar et al.). Few women are a part of the STEM labor force, and even fewer hold jobs in computer science. According to Margaret Pinnell, a professor in the Department of Mechanical and Aerospace Engineering at the University of Dayton, and Malle Schilling, a Graduate Research Assistant at Virginia Tech, stereotype threats negatively impact the performance of women in these jobs (Pinnell and Schilling). Stereotype threat, the pressure one experiences when a negative stereotype about one's identity could be confirmed by one's performance, leads

to women having lower self-efficacy in these fields. Conventional images perpetuating the idea that women should not pursue careers in computer science or engineering dissuade many women from pursuing these careers. Assembly Bill 1054 from the California State Legislature, reports that there are 49,040 open computing jobs in California; however, there are only 9,339 Computer Science graduates in California (California State, AB 1054). There are also salary discrepancies within the fields of computer science and engineering. A report published by the National Science Board of the United States, which establishes the policies of the National Science Foundation, which is an independent agency of the United States federal government, states that constant dollar median salaries for people with highest degrees in science and engineering have increased from $47,000 in 1995 to $57,000 in 2019 for women and from $69,000 to $86,000 for men ("The STEM Labor Force"). As science and engineering have become more crucial aspects of the workforce, these fields have experienced salary increases. However, though there was an increase in salary overall, women's salary increased by a smaller amount than men's salary and they still earn significantly less than men. These salary disparities reflect the broader challenges faced by women in computer science and engineering, fields where they are underrepresented.

There is a lack of women in the fields of computer science and engineering. Though many solutions have been implemented to increase the number of women in these fields, some of the most effective are female peer mentors, legislation, and nonprofits. Female peer mentors effectively increase retention of women pursuing computer science or engineering degrees, while legislation mandates widespread implementation. Although those are both important, nonprofits are the best method of addressing the lack of women in the fields of computer science and engineering as they ensure the widespread implementation of their solutions and can cater to specific demographics, increasing their likelihood of success and the depth of their impact.

Peer mentors are effective in increasing the number of women who pursue careers and college degrees in computer science and engineering. A study published by the British Psychological Society, a body charged with national responsibility for the development and application of psychology for the public good in the United Kingdom, reports that female peer mentors have been effective for female undergraduate students pursuing computer science or engineering (Reynolds). These female peer mentors are effective in what they do because the female undergraduate students who are receiving the mentorship are inspired by seeing people similar to them who are successful in the fields that they want to pursue. Furthermore, the presence of female peer mentors provides the undergraduate students receiving mentoring with an increased sense of belonging in fields where they are typically underrepresented. A research article published in the *Proceedings of the National Academy of Sciences of the United States of America (PNAS)*, a peer-reviewed journal, discusses a multiyear longitudinal field experiment in which female undergraduate engineering students were randomly assigned either a female peer mentor, male peer mentor, or no peer mentor. Those with a female peer mentor were shown to have increased levels of confidence, motivation, and retention in the field of engineering (Dasgupta and Dennehy). The benefits of female peer mentors are long term, they successfully help women retain their interest in engineering. Peer mentors may be helpful to undergraduate students; however, it is necessary to provide mentors who are equally supportive and conscientious. Moreover, though female peer mentors were shown to be successful, male peer mentors provided limited benefits and some disadvantages; therefore, male peer mentors are not as effective as their female counterparts. According to a report published in the National Science Foundation's Public Access Repository, peer mentors in a blended peer mentoring program were subject to complications regarding scheduling conflicts, time management, lack of faculty

facilitation, lack of program resources, and even limited technology skills (Rockinson-Szapkiw and Wendt). These challenges serve as a major obstacle to the effectiveness and viability of carrying out a peer mentorship program successfully. Though peer mentors are effective in increasing the retention of women in the field of engineering, they only target women who are already pursuing engineering and can be ineffective due to uncontrollable factors such as their own motivation and their gender.

Legislation has also been utilized to increase the number of women in the fields of computer science and engineering. Assembly Bill 1054, Pupil Instruction: High Schools: Computer Science Education Courses, is one such piece of legislation, to be implemented in California. This bill would ensure that by the 2027 to 2028 school year, all high schools in California offer a computer science education course. Bill 1054 outlines a timeline for computer science education course introduction into Californian high schools' offerings. The bill proposes that by the 2025 to 2026 school year, each school district in California must offer at least one computer science education course, and by the 2026 to 2027 school year, 50% of high schools per school district in California must offer a computer science education course. To address the possibility that not all schools may have the space and ability to offer a computer science education course, the bill mandates that these high schools offer a distance learning or virtual course option (California State, AB 1054). Bill 1054 introduces the opportunity to develop foundational knowledge and skills in computer science for all students, increasing students' critical thinking skills. Jackie Magno, an angel investor at an organization which funds exclusively women-led companies, states that these days, computer science is a fundamental skill. Everyone has to have access and exposure to this skill (Magno 2023). Though Bill 1054 has not been passed yet, the hope is that all students receive a fulfilling computer science

education and each student is allowed the opportunity to explore computer science. Though this bill seems to effectively address issues and proposes an enticing plan to get all students adequately educated in the subject of computer science, concerns have been raised regarding overburdened educators. A lack of already qualified computer science teachers would cause the burden of teaching computer science onto already overburdened teachers (California State, AB 1054). If these teachers are forced to learn computer science, they may only develop a superficial understanding of the concepts, leading to a lower quality of computer science education for their students. According to a book published by the Organisation for Economic Cooperation and Development, an intergovernmental organization and a reliable source of evidence-based policy analysis and economic data, excessive numbers of subjects and content cause overload. To ensure the depth and quality of students' learning, curricular content needs to be carefully selected (OECD). Teachers may feel overburdened due to curriculum additions, leading to students receiving a superficial education, diminishing the impact of and intention behind introducing new subjects into curricula. Assembly Bill 1054 proposes an effective method of providing the opportunity of an education in computer science to all high school students; however, it is not without its faults. Furthermore, as it is a form of legislation, the passing and institutionalization of this bill would mandate that all public high school students receive a proper education in the fundamentals of computer science, with no room for exceptions.

Nonprofits have also been effective in increasing the number of women in the fields of computer science and engineering. Black Girls Code, which targets Black girls under the age of 18, and the American Association of University Women's Tech Trek initiative, which targets middle school girls, have been successful in their endeavors. A case study published by the Rockman et al Cooperative, an independent evaluation, research, and consulting firm, reports

that girls who participated in Black Girls Code's programs reported wanting to continue coding and pursue tech careers, became more confident as coders, and displayed high levels of enthusiasm to expand their knowledge of computer science ("An Intimate Look"). Black Girls Code provides a racially and culturally aware computer science education to black girls, training the participants with a sense of belonging, and furthering their willingness to expand their knowledge. According to an article published in the *Journal of Extension*, a rigorous peer-reviewed journal, girls' interest in computer science and STEM in general tends to dwindle around middle school (Henry and Munn). As middle school interests inevitably lead to high school course selection, and by consequence, their chosen career path to pursue, middle school aged girls are a crucial demographic to address. In Oregon, the implementation of Tech Trek coding camps led to an increase in college-going rates and the girls in participation expressed an interest in STEM college majors, and by consequence, careers (Henry and Munn). Tech Trek successfully intercepts girls at this transitional age and increases their desire to pursue computer science. These programs, targeting unique demographics, allow participants to connect with their fellow peers and the curriculum at a deeper level, leading to heightened levels of self-efficacy and interest in the subjects covered, especially computer science and engineering. A research article published by Sage Publishing, an independent academic publishing company, by the Association for Research on Nonprofit Organizations and Voluntary Action, states that though nonprofits are effective in their implementation and reach of their demographics, issues regarding their funding may arise. As nonprofits rely on funding from outside sources, their funding can often become slow or unreliable (Hung and Hager). This is harmful because, without funding, these nonprofits would not be able to carry out their programs and inspire more girls to pursue careers in computer science and engineering. Nonprofits are an exceptional method of

tackling the widespread issue of few women pursuing careers in computer science and engineering as they are able to cater their services to specific demographics, increasing participants' sense of belonging and self efficacy, and can implement a variety of programs to increase the number of women in these fields.

Though there are many possible solutions to increase the number of women in the fields of computer science and engineering, nonprofits that cater to certain demographics are the most effective. Female peer mentors are effective in increasing undergraduate female students' retention in their chosen major; however, in order to be effective, the mentors must be conscientious. Conflicts regarding scheduling and uncontrollable factors may pose obstacles to mentees receiving fulfilling mentorship. Furthermore, male peer mentors are not as effective as their female counterparts, whose results are greater and more long-term, limiting the amount of mentors who would effectively increase retention of women in engineering. Legislation mandating offering at least one computer science course in all high schools ensures widespread implementation of all students being given the opportunity to take a course in computer science. However, this legislation may burden teachers who may already be overburdened. This burden may lead to a superficial understanding of computer science subjects for teachers and students alike. Though legislation would provide every high school student the opportunity to expand their knowledge in the realm of computer science, this solution is limited in that the education students receive would vary greatly from place to place and could end up not benefiting them. Furthermore, underqualified educators may lead to students retaining less interest in computer science than they started off with prior to the course. Nonprofits are able to cater to specific demographics, leading to increased sense of belonging and interest in the field. However, they rely on funding from outside sources, which can become unreliable. Despite this, nonprofits are

diverse and reach a variety of girls of differing ages to provide them with information about and experiences in the realms of computer science and engineering. Alumni of such nonprofits report increased levels of interest, self-efficacy, and willingness to pursue careers in the fields of computer science and engineering. The culturally-aware and gender-aware method that many of these nonprofits employ serves to provide their students with a sense of belonging, increasing their comfortability and willingness to participate in the activities that boost their interest in these fields. Nonprofits are the most effective method of increasing the number of women in the fields of computer science and engineering. Their ability to cater to specific demographics plays an important role in increasing girls' interest in these fields and their self efficacy. To become even more effective, they can diversify their funding sources. This ensures that the nonprofits always have funding with which to carry out their activities. Regardless of the specific strategy employed to increase the number of women in the fields of computer science and engineering, any efforts to increase this amount are important and play a role in solving this issue. The increase in the number of women in these fields not only increases the emphasis of women being capable of pursuing STEM degrees but would also serve to decrease the number of negative stereotypes associated with women in STEM fields, playing a role in bringing society’s perception of women to parity with their perception of men.

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