Empowering Girls in STEM: Developing an Intervention that Promotes Interest in STEM Topics

Gender Bias in Adolescence: Barriers to Girls in STEM and Initiatives to Overcome It

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On my honor as a University student, I have neither given nor received unauthorized aid on this assignment as defined by the Honor Guidelines for Thesis-Related Assignments.

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Introduction

Ada Lovelace, considered the first computer programmer, contributed significantly to the world of computer science at a time when opportunities for women in technical fields were severely limited. Despite designing an algorithm to calculate Bernoulli numbers for the Analytical Engine and being the namesake for the Lovelace Test based on her theories on the intellectual capabilities of computers, her achievements went largely unrecognized during her lifetime (*Ada Lovelace, a role model for the ages*, 2023). To this day, her significance and expertise is often questioned and criticized, mirroring the underrepresentation that women continue to face in scientific, technological, engineering, and mathematical (STEM) fields today.

In the 1970s, as women began to be admitted into universities in large numbers, a trend was set to increase their involvement in these technical fields and decrease the gap between the genders in both academics and the workforce. In 1970, women made up 38% of workers in the US with only 8% being in STEM areas. In 2019, these numbers increased to 48% and 27% respectively (Martinez and Christnacht, 2021). However, in spite of increasing opportunities for women in STEM fields, the desired rates of inclusion and interest have not, in fact, met our expectations. The increase in women working in engineering occupations has been slight and numbers have decreased for women holding computer occupations. The antagonist to our ideal STEM environment is the ever-present bias toward gender, which manifests a troubling paradox: “while STEM interest is rising, girls’ confidence in their STEM abilities is dropping” (Inc. (ROX), R. O. eXperiences, 2024).

In light of this paradox, my proposed STS project investigates how STEM-related gender discrimination during adolescence impacts the participation of women in STEM fields. Additionally, I will address how initiatives to encourage interest in these disciplines play a role in

addressing the barriers that discourage girls pursuing STEM fields. I will explore how different influences–such as parents, teachers, and peers–affect young girls' academic and career decisions in order to analyze successful methods to mitigate the negative effects of gender bias. If young girls participate in long-term, active learning programs where they are exposed to positive role-models, I expect the probability of them taking an interest in STEM topics and maintaining that interest to increase.

I will use the research as a basis to reflect on and evaluate an organization I co-lead, aimed to inspire young girls at a local Charlottesville, all-girls middle school to pursue careers in STEM, with an emphasis on computing sciences. My proposed technical project centers around the formation of this initiative and will deliver a reflection of the methods my team and I use to ensure we are effectively teaching STEM topics to the middle schoolers. Based on the initiatives explored in the STS project, I will determine how to measure the perceived success of my own initiative and make suggestions in regards to counteracting gender bias. In order to create an environment where young girls grow up passionate about STEM topics and confident to pursue their interests, the best methods to assuage deterrents and ensure long term engrossment in these fields must be determined. Only then can we look for a future in which the gender gap in the STEM workforce is permanently reduced.

Technical Project: Empowering Girls in STEM: Developing an Intervention that Promotes Interest in STEM Topics

As awareness of gender disparities in STEM continues to grow, organized initiatives have spread to impact women and girls from all walks of life, with Girls Who Code, Rural Girls in STEM, and SciGirls to name a few. These interventions utilize many different frameworks and designs, with a general consensus that participants should actively collaborate with those around

them, whether that be their peers or their instructors. Characteristics vary widely. Participation can be as short as 20 minutes to as long as an entire school year. Groups can be as small as 5 participants and as large as a few thousand. However, it is difficult to evaluate the effectiveness of each intervention, and oftentimes no evaluation will be carried out after the conclusion of the experience and no empirical data will be collected. Though there is this lack of clarity around describing an intervention and measuring its success, a 2020 systematic review of STEM interventions targeting secondary school girls used the resulting influence an initiative had on tertiary studies decisions to determine its success. Overall, it was concluded that "the development of a STEM identity is highly influential in engaging girls in STEM in the long term" (Prieto-Rodriquez, Sincock, & Blackmore, 2020).

As a participant in clubs similar to these when I was a young girl in elementary and middle school, the adults and peers I was surrounded by created an overall positive association with STEM disciplines. In October of 2023, I was given the opportunity to become a mentor myself and aid in the creation of an intervention like those discussed previously, eventually becoming co-leader. A professor at the University of Virginia in the CS Department was searching for a group of women studying Computer Science to mentor and inspire an interested youth at the Village School, a local Charlottesville middle school for girls. The group was gathered based on shown interest in response to recruitment messages sent out to different topic-adjacent clubs at UVA, such as Girls Who Code and Women in Computing Sciences. Initially, the professor communicated the goals and expectations of the club, but my fellow UVA students in the organization and I became more independent, holding planning meetings on our own and organizing the club internally.

The volunteer organization, now called Mentoring Girls in Computing (MGIC), offers introductory lessons in coding to students at the Village School. MGIC holds meetings on grounds at UVA to plan curriculum and visits the middle school for an hour each week to teach these lessons to the girls through hands-on, active learning experiences. We aim to foster positive relationships with the girls in order to inspire them to pursue futures in technology. By creating valuable and fun learning experiences, the mission is to show these adolescent girls that it is worth it to pursue their interests, no matter the obstacles they come across.

With the ongoing efforts to improve teaching methods and the research of effective interventions as a basis, I will deliver a long-term, computing-based initiative to encourage the participation of young girls in STEM fields. The proposed format of this deliverable is a document that encompasses the framework of the club with a timeline of the advancement of the curriculum. I will address in the writeup the limitations I encounter, such as the inability to collect direct empirical data from the participants. Additionally, the organization plans to branch out into other engineering disciplines through the use of activities such as Lego Education and the involvement of UVA women professors. Measures to ensure longevity of the organization will be developed by MGIC members, both in its participation of UVA students and partnership with the Village School. The creation of this intervention will be assessed on its efforts to mitigate the negative effects of gender bias, as well as its replicability for future years and outside interested parties.

STS Topic: Gender Bias in Adolescence: Barriers to Girls in STEM and Initiatives to Overcome It

While women's participation in STEM fields has made significant headway from 1970 to present day, as stated in the introduction, confidence in technical, scientific, engineering, and

mathematical skills have decreased even if a girl or woman expresses interest in the topic. A significant contributor to deterrence for women is gender bias, which remains a significant barrier for women and girls in STEM. A self-report survey across high school girls interested in STEM careers, women in STEM undergraduate programs, and women in STEM doctoral programs found that 61% of participants reported that they had experienced gender bias in STEM fields. Furthermore, this experience correlated to lower a STEM self-concept, with male peers being the most common source of this bias (Robnett, 2016). However, these harmful biases and stereotypes do not just pertain to girls in high school and higher education. Gender differences in motivational beliefs and career aspirations arise early in childhood, from as young as five to seven years old. While there is no difference in actual performance between boys and girls in these subjects, boys show a higher motivation in math and sciences (Lazaridesm, Oppermann, & Gaspard, 2023). These differences are shaped significantly by parents' and teachers' own stereotypic beliefs about gendered abilities, showing that it is important for young girls to be surrounded by mentors that encourage them and work against gender bias.

The research I will conduct in my STS project proposes a focus on the effects and mitigations of gender bias on adolescent girls, as children are divided by gender from a young age, with the separation being mostly solidified by high school. A range of reviews and analyses, such as the systematic review of interventions mentioned earlier, leads to the conclusion that there are initiatives which target adolescents that reduce this gender gap in STEM fields. However, a consensus on the characteristics and goals of initiatives proven to be effective have yet to be derived, due to "little empirical evidence" and "the heterogeneity of these studies" (Prieto-Rodriquez, Sincock, & Blackmore, 2020). When addressing the impediments that young girls face, it is also important to look at the research through a perspective of intersectionality, as

American academic Patricia Hill Collins states that "solving social problems within a given local, regional, national, or global context requires intersectional analyses" (Collins, 2019). It is known that gender, race/ethnicity, and socioeconomic status, or a combination of any of the factors, will affect the decisions an adolescent will make and their outlook on their personal experiences. When compared with white boys of a higher socioeconomic status, an analysis of "disparities in STEM career aspirations at the intersection of gender, race/ethnicity, and socioeconomic status (SES)" found that girls of all racial/ethnic and SES groups consistently held lower rates of interest and persistence in STEM fields (Saw, Chang, & Chan, 2018). Previous research on STEM career aspirations at the intersection of gender, race, and socioeconomic status, alongside research on effective interventions to increase female participation in STEM, can provide insight into how interventions should be personalized to adhere to the identities of the girls.

To gain a deeper understanding of how gender bias impacts female involvement in STEM fields and the role mediation initiatives play in addressing barriers adolescent girls face, I will analyze the characteristics of effective interventions through a variety of methods. First, I will conduct a meta-review on peer reviewed papers that discuss gender bias and gender disparity in STEM fields. This will provide insight to the origins of gender differences in youths and what factors might need to be addressed when reducing the negative effects of gender bias. I will also take into account secondary interviews and self-reflective pieces that delve into the personal experiences of girls and women in STEM, including the narratives of those that decided to pursue futures in technical and engineering fields, as well as those who ultimately decided to change their resolutions after expressing interest as a child. In these interviews, I will draw

comparisons between the personal influence of gender bias and interventions to the consensus provided in peer reviewed research and quantitative data.

Conclusion

Gender bias has historically been a key component in deterring girls and women from taking and pursuing an interest in STEM topics. While many interventions have been developed and implemented to break down the barriers that girls will face and address the gender differences in career aspirations, measuring their effectiveness is a difficult and continuous process. Thus, the gender gap in both academic and professional settings for STEM fields is an ongoing problem, despite a perceived push for inclusivity in schools and workforces. Long-term initiatives that involve hands-on collaboration are often desirable, which is the aim of the organization I have undertaken to expose middle school girls in Charlottesville to the possibilities of futures in STEM. In order to ensure that everyone is given the opportunity to pursue and develop their interests in an unbiased setting, unique perspectives must be analyzed and compared with existing research. Testimonies from women with a variety of backgrounds can be taken into account to draw connections between what factors encouraged them to pursue the careers they chose. Once successful interventions are developed, STEM fields can more effectively promote diversity and inclusion, leading to more innovative solutions to challenges.

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